VOLUME XL · NUMBER 9 · WHOLE 353

SCHOOL SCIENCE AND MATHEMATICS

DECEMBER 1940

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

Entered as second class matter December 8, 1932, at Menasha, Wisconsin, under the Act of March 3, 1879. Published Monthly except July, August and September at 450 Ahnaip St., Menasha, Wis.

PRICE. Two Dollars and Fifty Cents a year; foreign countries $3.00; current single copies 35 cents

Contents of previous issues may be found in the Educational Index to Periodicals.

SCHOOL SCIENCE AND MATHEMATICS

VOL. XL | DECEMBER, 1940 | WHOLE NO. 353

ADDITION BY DISSECTION

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In laying the groundwork for a course in the elements of Euclid we find it convenient, perhaps necessary, to establish congruence among plane polygons by "superposition." If the polygons are not "similarly placed" then superposition requires movement through a third dimension, a practice that is objectionable to conformists. The principle of superposition is also applied to establish the equivalence[1] of two dissimilar polygons of equal area. But this seems to imply the ability to dissect the two polygons into parts that are congruent in pairs—and in such a way that no part need be moved out of the plane.

The purpose of the present paper is to present the methods of dissection from this point of view and to indicate a process of addition that arises somewhat naturally. It is hoped that much of the following will find its way into the high school classroom where it might prove a stimulation of high degree. The maximum value herein may be realized only by constructing cardboard[2] models of the various dissections. These models will be found not only a source of satisfaction but also an intriguing jig-saw puzzle to "non-mathematical" friends. The paper cutter or photo trimmer is just as legitimate a mathematical tool as the ruler itself since it does nothing more than transform into a cut the line that has been constructed previously with straightedge and compasses.

[1] An over-burdened word in need of restriction.
[2] Colored "poster board" (about 14 ply) is excellent.

Certain fundamental dissections essential to later discussions are given under the headings I, II, and III. Many of the particular cases listed here are given by H. M. Taylor in *The Messenger of Mathematics*, 1905–06.

I. Transformation of a given triangle to one having a specified shape

Let P, Q be the midpoints of the sides AB, BC of the given triangle ABC, figure 1. In order to transform this triangle into

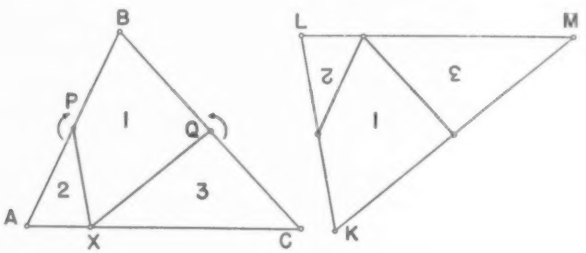

Fig. 1

one having a *specified side* KM, locate the point X in AC such that $QX=(KM)/2$. Cut along PX and QX and rotate the pieces as indicated by the arrows. A repetition of this dissection will produce a final triangle with *two* specified sides. Note that if X be selected so that angle AXP equals angle QXC, the resulting triangle is isosceles.[3]

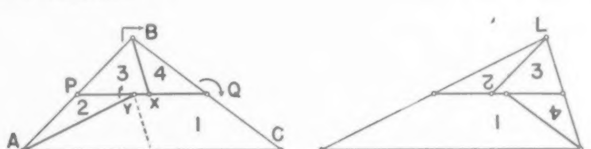

Fig. 2

The transformation of a triangle ABC into another upon the *same base* ($AC=KM$) and *having a specified angle* LMK, figure 2, is given by my colleague, A. A. Aucoin. Cut along PQ, the medial line of ABC as shown, then along BX such that angle BXP equals angle LMK, and finally along AY where RY is parallel to BX and R is the midpoint of AC. This dissection

[3] This dissection fails if $KM<(BC)\sin C$. But this failure can be avoided by introducing more cuts. Certain compatible conditions will be noticed by the reader in each of the dissections to follow. These are fairly obvious and no explicit mention of them is made.

is essential to the general theory since it implies the reduction of a polygon of n sides to one of $(n-1)$ sides. For, if the given polygon be . . . $ZABCD$ . . . , the triangle ABC may be transformed into the triangle ATC such that TC, for instance, is the prolongation of DC. Eventually, of course, this leads to a triangle of specified shape.

II. Transformation of a given parallelogram to another having a specified shape

To transform the given parallelogram $ABCD$ of figure 3 into another with specified sides KN and KL, locate the point

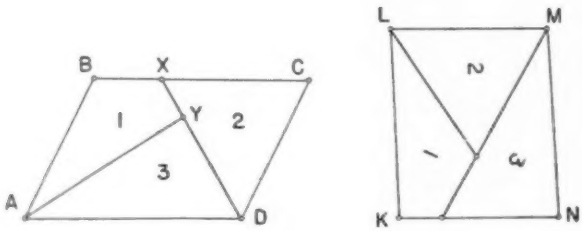

FIG. 3

X in BC so that $DX = KN$, then the point Y in DX such that $AY = KL$. The cuts along AY and DX produce three pieces to form the required parallelogram. The second point Y that may be constructed would lead to the reverse of parallelogram $KLMN$. If X falls on the extension of BC, the dissection yields more parts.

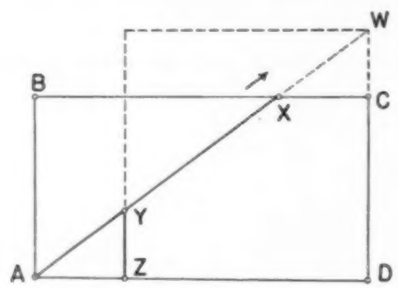

FIG. 4

A special case is of interest. If the given parallelogram is a rectangle, it may be dissected in the same way to form a square, where DX is taken as a mean proportional between the sides of the rectangle. AY is then perpendicular and equal to DX.

A second remarkably simple method is also given by Mr. Aucoin: Locate X on BC so that BX is the side of the square. Cut along AX and produce the line to meet DC in W. Cut YZ so that triangles AZY and XCW are equal. Leaving the pentagon fixed, the other two parts are moved from lower left to upper right into the position shown by the dotted lines. The same method applies, of course, to parallelograms.

III. Transformation of a quadrilateral to a triangle

Let P, Q, R be the respective midpoints of the sides AB, BC, CD of the quadrilateral of figure 5. Cut PQ, CX, RX where CX

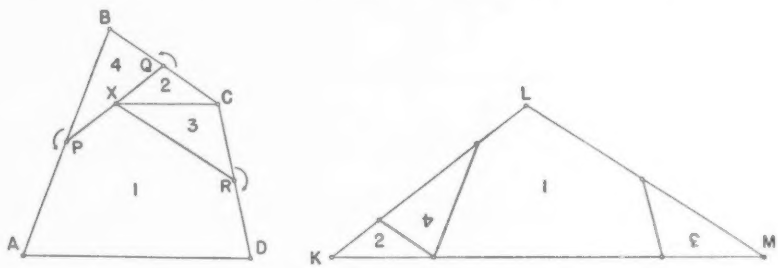

FIG. 5

is parallel to AD. If the parts be rotated through 180° as indicated triangle KLM is formed with one side coincident with AD.

A variation of the preceding dissection may be used to reduce a quadrilateral to a triangle KLM of specified shape. Let P, Q, R, S be the midpoints of the sides of the given quadrilateral. Construct the triangle QRZ similar to the desired triangle. Its area is one-fourth the latter and the point Z falls upon the line

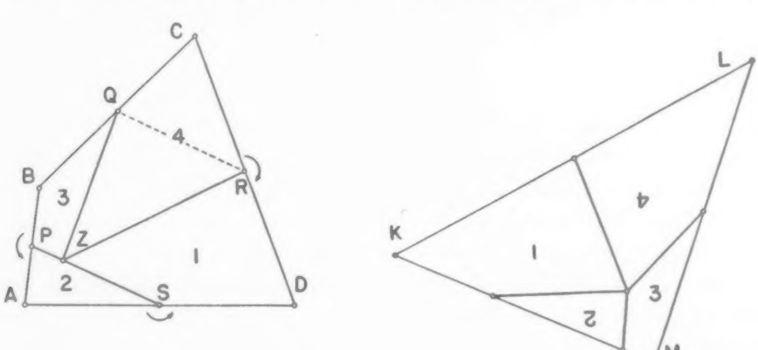

FIG. 6

PS.[4] Cut along *PS*, *QZ*, and *RZ*, and rotate the pieces as shown. Those with vertices at *Z* are the angle pieces of *KLM*. With but minor changes, this is the dissection of a square to an equilateral triangle illustrated in *Mathematical Snapshots* by H. Steinhaus (Stechert, 1938), p. 7 and first proposed by H. E. Dudeney in the *Daily Mail*, February 1st and 8th, 1905.

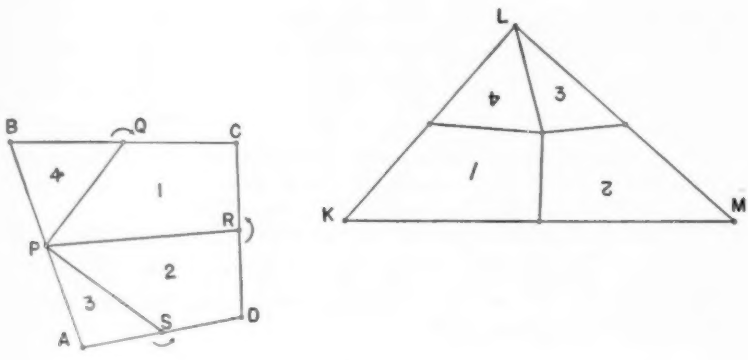

FIG. 7

A particularly simple reduction of a quadrilateral to a triangle is shown in figure 7. From the midpoint *P* of one side of the quadrilateral cut to the midpoints of the other three sides. Rotation of the pieces as indicated produces the triangle *KLM* with one side equal to a medial line of the quadrilateral.

The process of adding two or more given polygons by dissection now becomes apparent. To illustrate, we choose arbitrarily the addition of polygons of the same species.

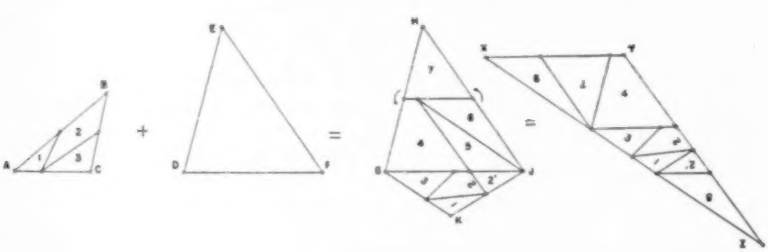

FIG. 8

(1) The addition of two triangles, *ABC* and *DEF*, figure 8, is accomplished by the method of figure 1. By joining the two

[4] See Problem 302, *The National Mathematics Magazine*, January 1940, p. 222.

we form the quadrilateral $GHJK$ which is reduced to the triangle XYZ in the manner of figure 5.

(2) The addition of parallelograms, or rectangles, may be indicated by the addition of squares. First transform one square,

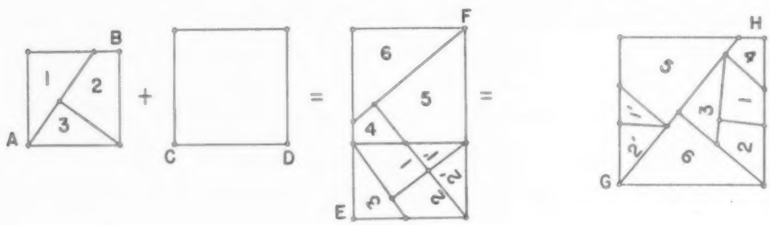

FIG. 9

AB, by the method of figure 3 (or 4) to a rectangle with one side equal to CD, the side of the second square. The dissection of this rectangle, EF, of the combined areas also follows figure 3 to produce the square GH.

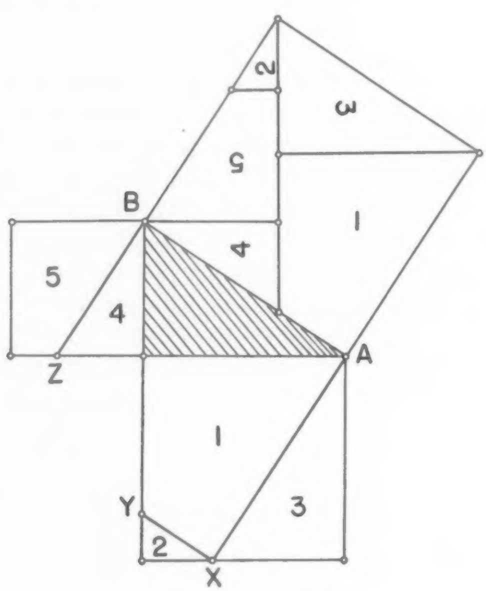

FIG. 10

However, the clue to a much simpler dissection is disclosed by the theorem of Pythagoras. Place the two given squares to form a right triangle as shown in figure 10. Cut perpendicular to the hypotenuse along AX and BZ, then parallel to the hy-

potenuse along XY. These five pieces may be assembled into the square on the hypotenuse.

There is the more general aspect of the theorem of Pythagoras: that the area of any polygon built upon the hypotenuse equals the sum of the areas of similar polygons on the legs.[5] The feeling is strong that a similar clue for a simple dissection should present itself in such cases.

The question of the least number of cuts or pieces to be expected in the general transformation by dissection of one polygon to another of equal area remains open and elusive.

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[5] Still more generally, the theorem is true for *any* three proportional areas.

CUNNINGHAM COMET WILL BE CONSPICUOUS AROUND NEW YEAR'S DAY

Conclusive evidence that the new comet discovered recently by Leland S. Cunningham, of the Harvard College Observatory here, will be the most conspicuous since 1910 is contained in his latest calculations of its path. These have been made public by Dr. Harlow Shapley, director of the Harvard Observatory.

They show that in early January, the comet will be easily visible in the western sky for an hour or two after sunset, as it passes south of the bright star Altair in the constellation of Aquila, the eagle. At that time, it will be about as bright as Altair, and possibly even more brilliant, though it is somewhat uncertain just what brilliance it may attain.

Its distance from the earth, at the beginning of 1941, will be about 60,000,000 miles, and from the sun about 50,000,000 miles. It will be at its closest to the earth about Jan. 10, when some 54,000,000 miles away, and to the sun, with 33,000,000 miles, on Jan. 16. Between these dates it will be most brilliant. However, it will then be so close to the sun as to be seen, if at all, only in the evening twilight. Consequently, it will not be as conspicuous as earlier, when it has a dark background. In the closing days of December, the moon, in a crescent phase, will pass to the left of the comet.

Though several comets in recent years were just barely visible when one knew where to look, this will be the first conspicuous naked eye comet since 1910. In that year there were two: Halley's, making one of its 75-year visits, and another which appeared earlier in the year, and was so bright that it was discovered independently in the southern hemisphere by a number of persons. Later it was visible in North America.

THE PRESENTATION OF ATOMIC STRUCTURE TO COLLEGE FRESHMEN, 1905–1940*

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The study of atomic structure followed as a natural consequence the proposal of the atomic theory. Looking over the history of this study of matter we wonder how man ever managed to delay his investigations for so many years. And, as we study the subject, we see how beautifully, scientifically and rapidly the problem is being attacked in our generation. In fact, proposals are being made, modified, further modified, rejected, revived, *et cetera* in such rapid succession we scarcely know what to tell our novices in the chemical field. This state of affairs has led to a cautious conservative approach to the subject on the part of general inorganic chemistry teachers. It is interesting to study their presentation of atomic structure and note the effect of each new proposal on the simplified presentation.

General inorganic chemistry instructors concede that the greater part of the work on atomic structure belongs to the science of physics, yet, since many of its details are essential for an understanding of chemical properties and principles, a presentation of the subject must be made. Just what constitutes the scope of this presentation is a question. In this work a comparison has been made of the dates of definite discoveries concerning atomic structure and the dates of their appearance in general chemistry text books. Outstanding texts in the field published between 1905 and 1940 have been carefully studied and the texts chosen have been for the most part those of scientists from the Middle West whose works are well known.

The atomistic theory as originally conceived by Democritus and Epicurus, developed by Lucretius, and resurrected by Gassende from about 1647 on was believed to be the source from which Boyle, in the seventeenth century, derived his ideas on the subject and from which Dalton, early in the nineteenth century, developed his well known atomic theory.[1] The structure of the atom began to claim scientific attention almost immediately after Dalton's development. His theory, which was proposed in 1808, was followed in 1815 by Prout's hypothesis that all the

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* Presented before the Chemistry Section of the Illinois State Academy of Science, Galesburg, Illinois, May 3, 1940.

atomic weights are integral multiples of the atomic weight of hydrogen. Until Aston's work and the discovery of isotopes Prout's hypothesis lay in disuse. It was shown, about 1897, that atoms might be composed of electrons[2] and since this time the wheels of atomic structure research have been in motion.

We expect the general chemistry texts written before and up to this period to say nothing of atomic structure. Scientists of the period were agreed that the atom was "the indivisible." However, with atomic structure research under way yearly changes in the concept of matter are seen. Lord Kelvin and Sir J. J. Thomson in 1904 developed a conception accoiding to which, an atom was regarded as a sphere of positive electrification of atomic size within which were embedded enough negative electrons to produce a stable body.[2]

This new and startling idea did not appear in the general chemistry texts of 1905.[3] They made no mention of electrons (positive or negative) or of atomic structure. Certainly the proposal must have created some stir among scientists! It was a brave and venturesome step for any scientist to take—to propose a word picture of the unseeable atoms! Since this conception was shown within a short time to be wrong in a great many respects we observe with surprise, but not with regret, that it did not appear in texts of the time. The texts of 1908 made the usual statements regarding the indivisibility of the atom, however, we find in one the footnote:[4]

> The latest investigations make it appear highly probable that the chemical atoms are not indivisible, that they consist of much smaller particles called electrons, and that some of these electrons may be split off the atoms. To all intents and purposes, however, the atoms of the common elements may be regarded as indivisible.

This was the first evidence of the teaching of atomic divisibility. Notice that about 1897 evidence pointed to the existence of electrons in atoms and eleven years later footnotes in general chemistry texts were making known the hypothesis. In 1909 the students were taught, "The electron theory has not yet been tested as to its value in the study of chemical changes."[5] At this time its existence was recognized.

Rutherford's proposal in 1911, upon which much of the subsequent work was based, was unique in that it completely discredited the work of Sir. J. J. Thomson concerning a "sphere of positive electrification." Rutherford suggested that "the atom consists of two distinct regions or parts, a positive center, or nucleus and an outer region in which the electrons occur."[2]

While the essential features of the Rutherford model of the atom received experimental verification and were generally recognized as accurate, great difficulty arose in the efforts to determine the arrangement of the electrons about the nucleus due to spectra peculiarities.

Two conceptions were developed almost simultaneously to explain this electron arrangement within the atom. In 1913 Bohr pointed out that spectra peculiarities could be accounted for by assuming the extranuclear electrons rotate in definite orbits around the nucleus instead of occupying fixed positions in the atom. Two years after the introduction of Bohr's concept Sommerfeld replaced the circular orbits of the Bohr atomic model by more general elliptical orbits, in one focus of which the atomic nucleus was situated. Contrasted with Bohr's theory, Sommerfeld's theory pointed to a greater variety of possible states.[6] The Bohr-Sommerfeld conception is referred to today as the "dynamic atom."

The "static atom," proposed by Lewis and Langmuir at about this time, described electrons in fixed positions about the nucleus in a series of concentric shells which could contain only a limited number of electrons in the outer shell of the atom. This did not account for peculiarities in the spectra.

At this same time work was being done on atomic numbers by the brilliant English physicist, Moseley.

The year following Bohr's proposal, that is in 1914, the students were taught:[7]

> The relations between the atomic weights of the elements and their properties which are brought out in the Periodic system constantly suggest that the elements must have some common origin and that the atoms are complex aggregates built up in some way from simpler parts . . . . It supposed that atoms of the elements are composed, in part, of electrons and that they may gain or lose these. . . . The electron theory is too recent for chemists to form a very positive opinion as to its value, but it is, at least, worthy of careful consideration.

This presentation was complete for college freshmen in 1914 and handled the subject most adequately. The author presented the material for which evidence seemed conclusive and avoided the question of arrangement which was one of controversy at that time.

In 1916 the value of atomic numbers was pointed out to general chemistry students[8] and though Rutherford's work was again discussed and nicely shown, the dynamic model of the atom was not mentioned. Since it has proved such a splendid

tool even at the present time, from the teaching standpoint, one is a little surprised to find its adoption so slow. Even in 1919 there appeared to be no general acceptance of the theories of atomic structure.[9] One author stressed the "reasonableness" of certain assumptions and of "almost conclusive" proof yet did not commit himself in any way. At that time there was a great amount of work being done to prove or disprove the static and dynamic models, yet no hint of this was given to the first year college students.

Students of 1923 were taught:[10]

> The atom is no longer regarded as a homogeneous entity, but as a system consisting of a core or nucleus, carrying a positive electric charge, and surrounded by a number of separate particles called electrons. . . . It was first assumed that the electrons revolved around the central positive nucleus much as planets and asteroids revolve round the sun, but the view generally accepted now is that they are held in a state of equilibrium by virtue of the interplay of their mutual repulsions and the attraction exerted upon them by the positive charges of the nucleus.

This statement showed definitely the influence of Lewis and Langmuir. It came at least five years after their proposal of a static stiucture.

The difficulties encountered in Bohr's conception were solved in a surprisingly simple manner by wave mechanics, founded in 1924 by Louis de Broglie. "The theory of de Broglie recognized in material particles nothing more nor less than the energy centers of some wave groups with which space is filled." (By "material particles" he meant protons or electrons.) Heisenberg in 1925 and Schroedinger in 1926 developed the wave mechanic theory as introduced by de Broglie and solved, at least for the time being, the difficulties encountered in the concept of Bohr and Sommerfeld.[11]

The problems of the nature of matter were pushed into the center of physical interest by the theories of Heisenberg and Schroedinger. Heisenberg's basic idea that the primordial particles of matter are not localizable was certainly of great moment and in Schroedinger's theory, too, the protons and electrons were no longer the sharply definable figures that they had earlier been considered to be. It is now believed that significant progress can be made in atomic study if the mechanical picture provided by Bohr is relinquished in favor of the less readily visualized but equally definite ideas of wave mechanics.

In the brief space of time 1923 to 1926 our ideas of atomic structure as first conceived by Rutherford were drastically

changed, yet, not until 1932 do we find mention of these changes in the text books for general chemistry students. In the texts appearing after 1923 an increasing tendency to explain electron arrangements is noted and the authors have all wisely refrained from undertaking and subjecting students to complicated physical discussion.[12,13,14] The nearest approach to our present day tenets is found in a text of 1932 in which the author says, " . . . the complete status of the present view of atomic structure cannot be stated in terms of a model but is expressed by the use of complex mathematical concepts."[15]

The author of a 1935 text summed up the situation in greater detail. He wrote:[16]

> At the present moment chemical thinking seems to be in a transition stage. We still speak of electron orbits and of an electron suddenly passing from one orbit to another; but we are convinced that things do not happen in just that way. So we resort to the equations of wave mechanics to deduce the probability that the system will remain in a given configuration or that it will pass into another configuration. At about that point we cease to draw pictures.

Also he pointed out to the student that the newer views of atoms developed since 1924 abandoned any attempt to form a mechanical model of their inner structure. He explained that the fundamental difficulty in picturing the electron as a little hard particle of negative electricity was that mathematics showed that no definite answer existed to the question of where one might expect to find a rotating electron at any particular minute. This at least was true of electrons in all but the outermost of the permitted orbits in an atom. Apparently the electron filled the whole orbit, as if it had the character of a wave. This 1935 text is as adequate in its presentation of atomic structure as any published to date for the college general chemistry student. Texts published in 1936 and 1938 add nothing to the 1935 splendid presentation.[17]

There is one text, published in 1939, which stands alone in its unusually detailed treatment of the subject, especially of the energy states of the electrons. The explanation for this fact was found in the preface in which the author states:[18]

> The author is convinced that a student has the right to expect of his general chemistry text more than a presentation of the minimum content of a beginning course. The book should be useful to him in later years, either in more advanced courses or for further reference in other connections. It is, consequently, not expected that the whole book be covered in any general chemistry course . . . . But many earlier chapters, notably those on atomic structure and on organic chemistry, are adapted to mak-

ing of selections, and some of them may be omitted altogether or in part for shorter courses without loss of coherence.

In his introduction to the subject of atomic structure this author gives us the usual picture of the atom with a positively charged nucleus surrounded by electrons, however, he does not describe orbits and in a later chapter he describes the energy states of the electrons and how these states are determined. The work, while very interesting, would probably be confusing to the average student. Only in a footnote do we find reference to the wave mechanic theory. The author says, "Electrons and protons also have certain wave characteristics which cannot, however, be discussed in this text."

An excellent text published this year gives what may be considered an ideal presentation of the facts as we consider they should be presented to first year college students at this time. To quote:[19]

> Brilliant as were Bohr's concepts, some basic defects were soon pointed out. If the electrons are moving at the high velocities that Bohr postulates, we cannot know, with any degree of certainty, where any electron is at a definite moment. Hence physicists have given up the idea of electron orbits in definite positions and no longer use a mechanical model of the atom. They have developed mathematical equations which express the properties of atoms and enable them to find probability of electrons being at a definite point at a definite moment. By such equations the probable distribution of negative charge in an atom is calculated and the probable greatest densities of charge are found at distances from the nucleus which correspond to the positions of the orbits as postulated by Bohr. The different energy levels of electrons which can be measured by spectrum analysis and in other ways, are properties of the atom, but they do not correspond to electron orbits in definite positions. They refer merely to the energy associated with electrons in the atom.

The descriptions of atoms which are acceptable to physicists at the present time can scarcely be called useful to the chemistry teacher. The increasing number of physical explanations necessary in the beginning courses tend to complicate an already intricate subject. For example, how can the general chemistry instructor hope to teach valence, types of valence, oxidation and reduction and the theory behind chemical reactions if he has no atomic models? The original Bohr atom is a "tool of great usefulness" to the chemist when he organizes and explains chemical data. Since the orbits of the Bohr theory agree with the most probable greatest density of negative charge, he should continue to use the modified Bohr theory merely keeping in mind that the circles he uses to show orbits refer to states of the electron with which he associates definite energy levels.

From this study we learn that chemistry text book authors have been slow to accept newer theories of atomic structure—indeed, any theories of atomic structure. They have proceeded cautiously, wisely and prudently and even at the present time find it possible to offer legitimate excuses for not relinquishing obsolete conceptions of atomic structure. This appears admirable in that the older conceptions have their pedagogical value. They may be used to great advantage to the students provided the new theories of wave mechanics are brought to their attention and the relationship between the new and the old ideas and their present respective values are adequately explained.

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THE PLIGHT OF HIGH SCHOOL PHYSICS

*V. Social Implications**

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. . . The school is simply that form of community life in which all those agencies are concentrated that will be most effective in bringing the child to share in the inherited resources of the race, and to use his own powers for social ends.[1]

* * *

. . . Most people never find out from the science teaching to which they are exposed why they do not share adequately the obvious benefits of science. Many acquire deep feelings of resentment and hostility toward this "science" which does indeed create new kinds of gadgets and comforts and jobs, but which also arouses desires doomed to disappointment and creates unemployment, insecurity, and bewilderment. Science promises everything, but leaves the individual in many cases empty handed.[2]

These two statements constitute a powerful program for science teaching—the first directly, the second by reversing its criticisms to form a positive plan. Science teaching should, in short, bring the child to share in the inherited resources of his race, to use his own powers for social ends, to learn why he and his parents do not share adequately in the obvious benefits of science and, by implication, to learn something of the way in which science may the more completely realize its possibilities for producing better living. The broad application of these precepts would cause a profound change in science teaching on the high school level. Immediately, it would require that the social implications of the material should be taught in all science classes, even in that course, physics, the rather sorry plight of which constitutes the theme for this series of articles.

To a certain extent this position has been anticipated in previous articles. "Water-Tight Compartments" (School Science and Mathematics 39: 840–845, Dec., 1939) suggested a teaching unit that would help the student to understand the significance of man's use of power; "Peccant Psychology" (School

* Other articles in this series have appeared in School Science and Mathematics as follows: Introduction. June, 1939 (39: 558–561; 1939)

I. "Water-Tight Compartments." Dec., 1939 (39: 840–845; 1939)

II. "Peccant Psychology." Feb., 1940 (40: 156–160; 1940)

III. "Mismanaged Mathematics." April, 1940 (40: 368–376; 1940)

IV. "The Languishing Laboratory." May, 1940 (40: 457–462; 1940)

[1] Dewey, John. *My Pedagogic Creed*. New York, 1897. Reprinted by the Progressive Education Association.

[2] Thayer, V. T. and Others. *Science in General Education*. D. Appleton-Century, New York, 1938, p. 225.

SCIENCE AND MATHEMATICS 40: 156–160, Feb., 1940) suggested a variety of material of social consequence in connection with safe-driving and the effects of noise on human beings; "Mismanaged Mathematics" (SCHOOL SCIENCE AND MATHEMATICS 40: 368–376, April, 1940) showed how the meaning of the important concept of energy could be clarified. In no case, however, was the selection of this content based upon the principles laid down in this article.

We need to spend little time justifying the suggestions to be made hereinafter through a critique of present practice. One illustration will suffice. Since the beginning of the present century six major industries have burgeoned into national importance. These are the telephone, automobile, airplane, motion picture, rayon, and radio industries. They employ both millions of workers and millions of dollars of capital. Their development has profoundly affected the character of American life. And yet any examination of texts and courses of study will reveal that we physics teachers have been content merely to discuss the principles involved in those five (of the six) industries to the development of which the field of physics has made a major contribution.

PHYSICS MATERIAL OF SOCIAL CONSEQUENCE

In the following sections I have attempted to suggest certain aspects of physics content that I feel have social importance. Evidently in a magazine article it is impossible to present the material in any complete fashion. The discussion is intended merely to suggest content which the class work will develop more extensively.

Energy and The Machine.

Man is supposed to have passed through several epochs in the march of progress from savagery to civilization. . . . The present epoch is called the "Age of Mechanical Power," and is considered by many as more important than the epochs which followed the introduction of the use of fire, the domestication of animals, the cultivation of fruits and grains, the discovery of iron, or even the invention of the printing press. Until the dawn of the "Age of Mechanical Power," man's capacity for work and production was limited by his own strength plus that of domestic animals. Mechanical power in the short interval of a little more than a century, by transferring reliance from animate to inanimate energy, has revolutionized the whole environment of human life by enabling man to utilize the energy and materials of his environment more effectively. Past civilizations rested upon human slavery; our times are dependent upon mechanical power and energy resources. In the finest civilizations of the past, leisure was afforded to the few by the hard labor of many human slaves. *Human slavery has*

given place in modern civilized lands to mechanical power, which has placed a new valuation upon human life.

Mechanical power, enabling man to do more work, and to do it in less time and more easily, has enabled the people of this country to develop in directions other than securing a mere existence. . . . In this "Age of Mechanical Power," a premium is placed upon the superiority of mind over muscle, and *human slavery is not only illegal but it is absolutely impractical because of the high cost of human labor compared with mechanical power.* A mechanical horsepower, costing $20 to $50 per year, substitutes for 10 to 15 human slaves; furthermore, a machine can operate continuously day after day whereas a slave cannot. Power means progress, relieving man of drudgery and enabling him to make the best use of his opportunities. Men now direct machinery by which work is performed.[3] (Italics mine.)

* * *

About the time of the Depression the automobile manufacturers were whooping it up with uncommon vigor. . . . But they were not making their own frames, it was far less trouble to let George do it, or more exactly, to let the A. O. Smith Company do it in Milwaukee. . . . Those frames were not only being produced in one plant, they were being made on what is essentially a single machine. When operating, this machine produces one completed frame every 8 seconds, fully 10,000 a day. The staff required is about 120 men "mostly in supervisory capacity." That is about 16 man-minutes to convert rolled steel strips to the underpinnings of a car. Throw in the estimated amount of labor to build the machine, maintain it and replace it when it is worn out and the surprising result is that the total labor investment is about 30 man minutes for each automobile frame. Here is an object worth from $50 to $300 with the labor of fabrication worth somewhere between 50 cents and $1. Our economic philosophy is tacitly based upon the assumption that a large proportion of the value of material objects is due to a man's labor and that a laborer should be able with his wages to buy back a considerable proportion of the objects he has made. *When the manual labor investment in a finished article represents less than 1 per cent of the total value then that theory breaks down and the social system tends to follow suit.*[4] (Italics mine.)

Evidently the development of the machine has not been without its effects upon mankind!

Man's use of the machine has been made possible by his control over energy. His control over energy resources is unquestioned. But what does this control signify? A recent book presents an interesting table.[5] It compares, among other things, the horsepower per capita in various countries and the civilization rank of those same countries in 1925 as determined from other criteria. It is interesting to note that, in general, those countries with the greatest horsepower per capita, are also those

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[3] National Resources Committee. *Technological Trends and National Policy.* Chap. V, Section III "Power" by A. A. Potter and M. M. Samuels. U. S. Gov't Printing Office, Washington D.C. 1937. pp. 261–262.

[4] Furnas, C. C. *The Next Hundred Years.* Reynal and Hitchcock, New York, 1936. p. 342.

[5] Eavenson, H. N. *Coal Through the Ages.* American Institute of Mining and Metallurgical Engineers, New York, 1935. p. 111.

with the highest civilization. Recent estimates show that energy is available in the U.S. at the rate of about 10 horsepower per capital. The average family with its 40 horsepower controls the equivalent of 400 slaves—and this without the sale of a single person at the auction block! Available to each of us is energy at such a rate, on the average, that every second it could hoist an object weighing nearly a ton three feet into the air.

We look into the future and hypothesize an existence in which more and more of the routine drudgery is lifted from the back of mankind. Such a future is dependent upon a continued supply of energy. Is the supply adequate? In one sense of the word it is foolish to think of running short of energy, since the sunlight that falls on the earth in one single minute is adequate to supply the world's heat and power requirements for an entire year. However human ingenuity is lacking and we are not able, as yet, to use the sun's rays directly in any large way. For the present, at least, we must depend upon that indirect use of the sun's energy which is involved in our use of fuels. We value fuels because of their great energy content. A pound of coal contains about 14,000 B.T.U.—enough energy could we but make it all available, to hoist a class of 30 students about a mile into the air. Gasoline contains more energy, pound for pound, than the most fearsome of modern explosives.

But already we are concerned about our decreasing fuel reserves. To what shall we turn? To an increased use of water- and wind-power? To the use of plants for fuels, either directly as when powdered corn stalks are blown into boilers, or indirectly as when we make alcohol by the fermentation of grains or molasses? To tidal energy? To one or another project using the sun's energy directly? This is a problem with which scientists, and governments, and their peoples—yes, and even high school students must become concerned. The growing demand of many individuals and groups that the Federal government take steps toward the establishment of a sane and comprehensive national power, or energy, policy attest to the growing national interest in such problems.[6]

In this, and subsequent suggestions, the point may be made that we are taking over material that has been taught in social studies classes. We must be careful, of course, to avoid wasteful duplication, but it may be argued that the social import of

[6] See for example: National Resources Committee. *Energy Resources and National Trends.* U. S. Government Printing Office, Washington, D.C. 1939. pp. 30, 423.

technological developments, such as the machine, may best be understood when we also understand what the machine really does. Physics shows what the machine does, and explains how it works. Why not do some, at least, of the rest of the job also?

As part of this treatment the concepts of *work, power, energy, the machine*, etc., are taught as they have not been before. Not only must the usual, rather limited understandings be developed but, through continued and varied use, students should develop a full and richly appreciational understanding of the significance of these concepts. No longer are they mere words in a text but an integral and dynamic part of life in America today.

Electricity. Electricity is unique. It exists only while being consumed! It is the one form of energy that may be transmitted efficiently over long distances. Let us imagine that the power companies had to supply the energy of our community by mechanical means. Miles of belts, pulleys, supports, with all their attendant danger and inefficiency would be necessary. An impossible situation! On the other hand so efficient is the transportation of electrical energy that scientists often envisage a future in which coal is burned at the mines to produce all the electrical energy needed in metropolitan areas. Think of the effect of such a practice on the cleanliness and health of cities.

At the present time the best steam plants produce one kilowatt-hour of electrical energy for a little less than one pound of coal as compared with $3\frac{1}{3}$ pounds for the average plant in 1918, 5 pounds in 1900, and 10 pounds in 1880. What is the limit? It evidently depends upon the real significance of the "one kilowatt-hour per pound of coal." Just how efficient is such a plant anyway? A calculation reveals how far we are, after all, from really high efficiencies in electrical production.

In 1938 about a million and a half of the farm homes were receiving electricity from private and publicly owned utilities. Large though that may seem, it represents only about $\frac{1}{5}$ of the total number of farm homes. What an effect upon the manner of living of that sector of the American population if something near all such homes could be electrified!

Light. Social material here seems to center around two emphases—upon the safe and desirable lighting for home, factory and highways—and upon the improvement of lighting sources.

The eye of man is poorly adapted to the use to which it is put. Evolutionary development has produced an organ which

is designed for distant vision out-of-doors where illumination levels of thousands of foot-candles prevail. We use our eyes, most characteristically, for close work, indoors, under levels of a few foot-candles. The problem is aggravated by the fact that the eye is fundamentally different from our other sense organs. Strain as hard as you please to smell the weakest odor, to taste the weakest flavor, to hear the faintest sound and no harm is done. Strain to read by light that is too dim and irreparable damage may result. Apparently what is needed is a general increase in the amount of light that we use for seeing, together with an improvement in its quality (elimination of glare, etc.). Safety on the highway is seen to be integrally related to an increase in the amount of light provided to light the road at night.

The defect in most electric lamps lies in the method used for producing light, that of *incandescence*. In order to make the filament give off light, we must first make it red- or white-hot. Of the energy we put into the ordinary 40-watt lamp, only about 8% appears as radiation that we can see. The other 92% is either heat or radiation of a type that is not effective visually. Is this the best that man can do? As Furnas has put it

> . . . the beaming rump of the lighting bug is just 8,000 times better than the head of man in the matter of light production.[7]

We need to devise other, and better methods of producing light. The method employed by the firefly, *chemiluminescence*, might serve. Or we may turn to the *electroluminescence* of the neon and similar signs. Mercury-vapor lamps of this type have long been used. A recent lamp of this type gives some seven or eight times as much light per watt as do ordinary home sizes of incandescent lamps. Another type that may offer much for the future is the *fluorescent* lamp, typified by the tubular lights, without filament in the ordinary sense, that have appeared on the market within the past few months. Several times as efficient as the incandescent lamp in white light units, in one of its colors, green, it actually produces 150 times as much light per watt as do green incandescent lamps. The explanation of such unusual light productivity offers a rather nice problem for the high school class to investigate.

Heat. The statement has been made that modern civilization can develop only in the temperate zones. The climate of torrid and frigid zones is held to be such that man's inventive and

[7] Furnas, C. C. op. cit. p. 252.

esthetic talents are inhibited in those regions. Man can live in temperate zones only if he finds means for keeping warm. Two things are requisite—fuel to burn, and a device in which to burn it and which will circulate the heat throughout his home. In how many physics courses do students sense that the heating systems which they study may be a *sine quâ non* for the culture in which they live?

We spoke earlier of the fact that since 1900 the development of six great industries has profoundly affected the life of our time. Some people see in air-conditioning a seventh (with television a possible eighth) industry of scope equal to the other six. Let us therefore teach the principles on which air-conditioning operates but let us also note the profound effect its widespread use may have through:

(1) the establishment of a new industry in an economy which badly needs whatever stimulation that may give,
(2) the effect its use may have on our ways of living.

What change in life in the temperate zones and what profound changes in the torrid!

Sound. In the third article of this series, "Peccant Psychology", there was some little elaboration of material dealing with the effect of noise upon human beings. To this we need only to add the additional fact that studies seem to show that persons work less rapidly and with reduced accuracy and an increase in wasted energy, under noisy conditions. The human body is marvelously adaptable, and we can adapt ourselves to work under conditions of rather extreme noise. But we pay for it in tired nerves, fatigue, and a possible impairment of hearing. Thomas Edison, himself deaf, although from another cause, predicted for the human race an increasing amount of deafness because of the senseless din which assails our ears.

Consumer Education. Science classes have been urged on many occasions to do their share in contributing to that education which will be of greatest value to the student in his activities as a consumer. At many points in the physics course, this probably becomes synonymous with emphasizing the social implications of the science material. A case in point might be the consideration of the value of fog lights. Objective examination of the data seems to show that any light close to the road is of help, but that the interposition of a yellow filter before the headlight lamp in order to produce a yellow beam, probably does not materially help to penetrate the pall of fog.

Physics and the Community

If we are to make these social emphases really felt a new orientation of the physics course is needed. I use the word new, not because the idea I am about to suggest is really novel, but because the application of the idea has rarely been made. The physics course must look outward into the community. An obvious first step is to take the class into the community, to leave the cloistered classroom. We have made excursions in the past, usually to industries where some of the principles discussed in the course are exemplified. But have we made a study of the extent to which electricity is being used advantageously in the homes of the community? Have we ever studied the electric rates paid by consumers in an attempt to ascertain their fairness? Or studied lighting conditions on the highway, in relation to accidents? Or prodded the city fathers to enact noise legislation, or to enforce that already on the books? Not all of these may be possible, or desirable to do in our situation. Others may be suggested. But are we doing any of them? A recent report lists eight different kinds of activities of direct concern to the science program that have been carried out in various schools or by various groups of young people.[8] Only one of these, a smoke-abatement campaign bears even a close resemblance to an activity that might have been inspired by a physics class. The field is wide open for your venture.

Physics Redivivus

To a certain extent it must be admitted that the present discussion is something of a tour de force. We have attempted to show how social emphases may be brought into a course already in existence—a course which may not be sufficiently elastic in its very nature to permit of their admission. That is not to be taken to mean that the writer has been insincere in suggesting these changes or innovations. It is just that the plans that are herein suggested are, in many instances so broad in their scope that they need to be dealt with in a course that affords a larger amount of time, and a larger degree of freedom than does any single conventional course. One can easily become excited about the prospects of a whole grade of the high school really trying to do something about some such problem as the noise of the community, or the effect of the development of the machine

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[8] Hanna, Paul R. and Others. *Youth Serves the Community*. D. Appleton-Century, New York, 1936. pp. 95–117.

upon the community, and in so doing devoting the larger part of the school day to the task. To such activities the subject, physics, can make real and vital contributions. Can they be made within the framework of the traditional course? In some exceptional cases, the answer may be "Yes." In most cases, I suspect, the verdict will be that a new organization of the curriculum is necessary. Perhaps, after all, a great deal of what we have been pleading for in the present article can only be realized when we physics teachers have achieved sufficient vision to be willing to make drastic changes in our subject, possibly even to the forgetting of our vested interests and allowing the subject to merge its identity in some more functional organization of the curriculum.

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SCIENCE SERVING THE STUDENT

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This is a day of specialists. Science has made it so. The more discoveries are made, the more technical our information becomes, the more necessary does specialization become if one is to succeed in any particular line. So great has become the volume of technical knowledge in every line that we no longer accept the authority of the generalist but insist on the specialist in medicine, engineering, chemistry, physics, botany, zoology, geology and every other field. We no longer can learn all that is known about any one of these fields; it would take a lifetime to master one branch of knowledge in science. Every new discovery is added to our store of knowledge, every new method and device make further specialization necessary, and the vicious circle becomes the more vicious as we try to find our place in it.

This great specialization has carried over into industry. No longer do we attempt to supply our own individual needs but produce some little product or service in the great industrial machine. Great industries have arisen due to improved methods, products, and distribution. Backed up by patents and machinery they have tended to drive the small producer from the field. Power tools require organization of industry and workmen and markets on a larger and ever larger scale.

There have followed new methods of employment for youth. The old apprentice system or the father-son plan cannot be used in big business. The father cannot take his son into the factory or office with him because of labor laws. This requires that the boy be trained outside of the place that is ultimately to employ him, with perhaps a short period of specialized training as he begins his work. The long period of youth in which most kinds of training must begin if they are to be most effective will be lost unless the schools assume the obligation of training youth for life industries and vocations. Larger numbers of boys are being kept in school longer, boys who ought to learn a trade, boys who want activity and to whom the average classroom is a waste of time, boys who need to learn how to operate machinery, boys who want to understand technical science and industry and will succeed only if technically trained.

If we accept the general philosophy that the schools should serve community needs, it must follow that the schools should

train boys and girls to take their places, not just the white-collared positions, but the places in the shop, on the farm, in industry. We have enlarged our industrial arts department for boys. We have increased our home training for girls. But there is more that can be done. There is more that should be done if the schools are to keep up with progress. It is interesting to note the many specialized courses now being offered in high school. In commerce, we are training bookkeepers, typists, operators of office machinery, and many technical types of office work. In industrial arts we are training architectural engineers and machine draftsmen with many courses that require two years of continuous work in one specialized field. Only a few years ago woodwork and metal work with a course in mechanical drawing were about all that a high school student could expect to receive in this field of study.

Since the greatest progress has come in the field of science, it seems that any progress should be reflected in this department. Our scientific age requires that the science department keep up with industrial progress which science has made possible and necessary. If we are to find the problems which the science department should help solve, we must find them out in life. Those who will be able to solve these problems are those who are solving them in the work-a-day world. We shall find our information in the community in which we live rather than in books, among business and industrial men rather than among educational leaders. The educational leader has too often become a specialist and knows education only. He has spent too much time in the classroom and too little time visiting shops, laboratories, and industries trying to learn the latest in scientific information. Our textbooks contain what is known in the particular field several years after it has been discovered in the research laboratory.

Most of our present science books are history books, the history of science. The student is led to rediscover the law of gravitation which Newton discovered 300 years ago, or Boyle's law, or the principles of photosynthesis, or the processes of digestion. There is so much to learn about valence that the student in chemistry has little time for applied chemistry in the home and industry. The applied chemistry is held for the advanced courses after the student gets into college. We spend our time laying the foundation and never get much of a building on it for the average student. While the world outside is becoming more and more specialized, the average high school science department is be-

coming more generalized. We have lost botany and zoology for the boy or girl who wished to study plants and animals and have substituted a general biology which, because of the nature of the course, must be devoted almost exclusively to human biology. There is so much to learn about forestry, flowers, birds, insects, fish, reptiles, mammals, that the high school student who is so inclined to study would be glad to know if given the opportunity. The beautification of home grounds, enjoyment of life in the out-of-doors, can best be done by the one who is informed.

We are on the verge of losing chemistry and physics in the trend toward physical science. Perhaps it is because the old courses refused to be changed from college preparatory courses to life-preparatory courses. Whatever the cause, we are going in the direction of generalization rather than in the direction of specialization. The teacher in physics or chemistry has had a difficult time knowing the one field, particularly the industrial angle. To know both fields will be more difficult. The teacher cannot teach what he does not know. The laboratory cannot be fitted for all kinds of work. By attempting to cover such a genalized field, there is danger that we shall lose the laboratory entirely. Our course will become a *social science* course rather than a *natural science* one. The list of references will increase and the the microscopes, test tubes, and balances will be lost in the shuffle. We shall spend our time trying to teach scientific thinking without giving the student any science information with which to think.

Our classrooms will become playrooms instead of workrooms. We shall train more people for the PWA because we are not giving definite training for any specific kind of work that the world needs. We shall have adopted a soft easy-going philosophy and we shall awake to find our civilization, that depends so much on science, lost to many of our people and the schools will be to blame because they "missed the boat." There is a place for the general science course. It may particularly suit the needs of the student who is going to college or who is not going to enter technical science work in industry. It should be offered for those who wish to generalize before they are ready to specialize. But for many of our students all the organized science they will ever have, they must receive in high school. We cannot afford to hold all the useful science courses on the college level. Our agricultural colleges and engineering schools cannot train the great mass of our students because relatively few will enter them.

If we are to provide the type of science courses that are needed by those students who will not go to college, we should not go to college to find out what kind of courses to offer. Rather we should go out into industry to find the materials and information that should be organized into courses. Each community should take an inventory of the community science needs and try to minister to these needs. The rural community will not be the same as the urban community. The mining region will not have the same needs as the manufacturing region. The small school community will not have the same problems as the large metropolitan community. In all schools which see the opportunity and try to meet the responsibility, there will be much that can be done and it does not matter where the start is made. Mistakes will be made but the greatest mistake will be to do nothing, to bury our heads in the sand. The courses may be long or short according to the nature of the course and the needs of students. It is the diversity of human interests and abilities that has made our great industrial progress possible. It is the unlimited human wants and needs that keep it going.

Who is to be the judge of what courses to offer? Only student needs based on community needs can determine what should be taught. It may be that no new courses are needed but rather that the present courses should be streamlined to suit modern needs. It makes little difference what we call a course except for college entrance. If we are to give a diploma that is not to be used for college entrance, it makes little difference what subjects are used. The needs of students expressed by electives which they select personally from a wide list of possible courses would seem to be the best approach to the problem.

There is a shortage of skilled workmen, so we are told by industrial leaders, and this shortage will increase if our present tendency to generalize continues. There is much inefficiency in living conditions and working conditions among most of our people in spite of the great discoveries of science, and the inefficiency will continue unless the schools come to the rescue. If we could but apply the science that is known, we should become more efficient in every line. Knowledge about the common fundamental human needs, the need for food, clothing, shelter, communication transportation, home living, family life, health, and leisure will help us all to take advantage of the scientific age in which we live. We cannot learn too much and we cannot apply what we know too well.

NEW NUMBER SYSTEMS VS. THE DECIMAL SYSTEM

J. T. Johnson
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Articles have appeared from time to time on number systems other than our decimal system. An aticle by E. M. Tingley entitled "Calculate by Eights, Not by Tens" appeared in this Journal in April, 1934. Since then in October of the same year, an article by Emerson F. Andrews appeared in the *Atlantic Monthly* under the title, "An Excursion in Numbers." That article, as suggested by its title, was very interesting and enlightening to many people in broadening their horizon of number vision and extending the understanding of our present number system.

In 1935 Andrews published his book on *New Numbers* in which he becomes quite enthusiastic about the duodecimal system. It is a cleverly written book and a valuable one for setting forth the possibilities of that system.

Now comes Mr. Tingley again with an article in the June, 1940, issue of this journal advocating the Octonary system under the caption, "Base Eight Arithmetic and Money."

Both Andrews and Tingley, it seems, have been carried away from realities by their enthusiasm for these idealistic number schemes in that they apparently think that it would be possible and even probable for the human race to adopt either the duodecimal or the octonary system.

If it were possible and probable for a number system with an entirely new base to be adopted the writer would be inclined to favor the octonary to the duodecimal system for the reason that its fractions as Mr. Tingley points out are all based on the half and also because it needs no new characters. One wonders why Mr. Tingley chose the octonary rather than the quaternary or the binary system. The binary system has some wonderful advantages in its applications not to mention its extreme simplicity.

It is not the purpose of this article to explain a new number system or to discuss the relative merits of new number systems. When it comes to a proposal of changing such a fundamental habit of thought as our number system all angles of approach and relative values should be carefully considered. Hence the writer wishes to point out some statements made by Mr. Tingley

in the June issue of this journal that may be misleading to many readers as well as some misrepresentations that should be corrected.

Mr. Tingley starts out with;

> Eight is the best base for our arithmetic, not ten or twelve.[1]

This is an unsupported statement. No proof follows that establishes eight, even if considered theoretically, as a better base than four or two. Again when he says,

> Our minds prefer halves, the even divisions of things. Material things divided into fifths as in the metric system and in thirds and fifths in moneys are difficult for our minds.[2]

he is slightly misleading in that in the metric system, as everyone should know, things are divided into tenths not into fifths. When he refers to "thirds and fifths in moneys are difficult for our minds" it *is* difficult for our minds to know what he means. In the first place our money is not divided into thirds and fifths but rather into halves, quarters, tenths and hundreths, and there is no evidence that our money is difficult for our minds since it is based on exactly the same base as our natural number system which is ten.

His next dogmatic statement is:

> Psychologists and not calculators, teachers, arithmeticians, physicists, or legislators must decide what is the best base for our arithmetic.[3]

The writer asks again, where is his evidence or proof? Then note what is said in the very next paragraph.

> Psychologists have entirely neglected the arithmetic bases but they must find that eight furnishes the best "all-round" mental handle for the preferred fractions, halves and halves of halves of halves repeated indefinitely.[4]

One wonders why he wants the psychologists to decide on our number base when they "have entirely neglected the arithmetic bases." He is seemingly motivated by a strongly optimistic faith in them as he says "they *must* find that eight furnishes the best all-round mental handle, etc." (Italics are the writer's.)

Other inconsistencies are found but let us now examine some other statements and their implications made by Mr. Tingley.

> As tenths of things are not acceptable to our minds the metric system measures guns and houses in integral millimeters.[5]

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[1]. School Science and Mathematics, June 1940, p. 503.
[2] *Ibid.*, p. 503.
[3] *Ibid.*, p. 503.
[4] *Ibid.*, p. 503.
[5] *Ibid.*, p. 504.

Where he gets the proof that "tenths of things are not acceptable to our minds" is not known but the writer knows that fractions in any form, whether common or decimal, are much more difficult for children to learn than whole numbers. (The writer has had direct contact with children learning arithmetic for over twenty-five years.) That is just why the metric system scores an advantage for the common person because he can discard fractions entirely if he wishes and work with whole numbers—the integral millimeter mentioned above, the integral gram and cubic centimeter.

In the next paragraph we find;

> The decimal and metric systems lack the easy use of halves, quarters, and eighths over the entire range of measurements.[6]

It is difficult to reconcile this statement in the face of .5, .25, and .125. Even if the layman wishes to use the common fractions, $\frac{1}{2}$, $\frac{1}{4}$, and $\frac{1}{8}$ there is nothing in the base ten system that prevents him from doing so. Haven't we been using halves, eighths, and fourths with our base ten system for hundreds of years?

Mr. Tingley keeps repeating the statement that we prefer halves, the mind prefers halves, as the easiest fractions. It is clear that Mr. Tingley prefers halves but can he speak for the rest of the world? Of course the half is the easiest fraction. Everyone knows that, but what would happen to technological progress if nothing but halves and halves of halves were to be used? Such statements as these are found;

> We like halves of things because we ourselves are closely related to halves through our symmetrical bodies, our two hands, and two eyes, by which we perceive things.[7]

It is very doubtful whether bilateral symmetry has any connection with the fraction $\frac{1}{2}$, but even if we grant that it has we must accept the fact that the ancient Hindus who originated our present decimal system used their ten fingers and other tribes used their fingers and ten toes when they founded the base of their number systems. Since they had their two eyes and their two hands, why did they not use them as number bases? Perhaps manipulation was more pertinent than perception when establishing a number base.

Again we find;

> We like to think of halves in our native mind language but we must now

[6] *Ibid.*, p. 504.
[7] *Ibid.*, p. 505.

write halves in the foreign language of fifths and tenths of the decimal and the metric systems.[8]

We ask, are tenths of the decimal system a foreign language to our children who play and buy with pennies, nickels, and dimes from the time they enter school? We are afraid a system based on eight would be foreign to them indeed. How would you like to add as follows: $\begin{array}{r}4\\ \underline{4}\\ 10\end{array}$; $6+7+4=21$; or subtract like this: $\begin{array}{r}62\\ \underline{15}\\ 45\end{array}$; $\begin{array}{r}\$1.10\\ \underline{.75}\\ .13\end{array}$: or multiply this way; $\begin{array}{r}42\\ \underline{6}\\ 314\end{array}$; $\begin{array}{r}76\\ \underline{7}\\ 662\end{array}$?

To quote again;

> Division of numbers by ten in the decimal notation is of course easy. But tenths give us fifths and who divides a thing into fifths if it can possibly be avoided? The fifths of money and of metric scales are to fit the decimal base, not our minds. They are provided for us, not by us.[9]

What does he mean by "for us not by us?" They must have been provided for us *by* some one. By whom? The answer is, by those who sought to make computation and measurement easy by relating it to our natural number system based on ten.

Let the reader judge this statement;

> We are now denied the use of halves, our preferred fractions of things, half of our powerful number tools by the use of ten as a base.[10]

Then he summarizes;

> As a summary we find that the preferred even fractions and division decide that eight is the best base for our arithmetic.[11]

That is final.

Let us now pass to Mr. Tingley's discussion on money. He seems to be confused about the base in our money system as he repeatedly refers to fifths instead of tenths. Witness the following statement;

> Our U.S. Money is an application of the decimal and the metric principle. However inspection shows that fifths are here avoided and halves are favored. The accompanying tabulation of the ratios in the coinages of the world shows the same tendency.[12]

The whole table is here reproduced as given by Mr. Tingley for the sake of completeness.

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[8] *Ibid.*, p. 505.
[9] *Ibid.*, p. 505.
[10] *Ibid.*, p. 505.
[11] *Ibid.*, p. 505.
[12] *Ibid.*, p. 506.

MONEYS OF THE WORLD[13]

Ascending Ratios Between Coin Values

United States	5	2	5/2	2	2	5/2	2	2	2				
Canada	5	2	5/2	2	2	5	5	2					
France	2	5/2	2	5/2	2	2	2	5/2	2	2	5		
Scandinavia	2	5/2	2	5/2	2	2	2	5/2	2	2			
Netherlands	2	5/2	2	2	5/2	4	5/2	2	2				
Belgium	2	5/2	2	5/2	2	2	2	5/2	2	2			
Switzerland	2	5/2	2	2	5/2	2	2	5/2	2	2	5		
Italy	2	2	5/2	2	2	5/2	2	2	5/2	2			
Spain	2	5/2	2	2	2	5/2	2	2	4/5	4			
Austria	2	5/2	2	5	2	2	25/2	4					
Czech	2	2	5/2	2	5	2							
Finland	2	5/2	2	2	5	2	10	2					
Greece	2	5/2	2	2	5/2	2	2						
Hungary	2	5	2	5/2	2	2	5/2	2	2				
Turkey	2	2	2	2	5/4	2	2	2	5/4	2	2	5/2	2
Argentina	2	5/2	2	2	25/2	2							
Brazil	2	2	5/4	2	2								
Mexico	2	5/2	2	2	5/2	2	5	2	2	5/2			
Cuba	2	5/2	2	2	2	5/2	2	2	5/4	2	2		
Venezuela	5/2	2	2	2	2	5/2	2	2	5				
Uruguay	2	5/2	2	2	5/2	2							
Chile	2	2	5	2	5/2	4	5/2	2					
Algeria	2	5/2	2	5/2	2	2	2	5	2	5			
Japan	2	2	5/2	2	2	5/2	10	2	2				
Great Britain	2	2	3	2	2	2	5/4	4	2				
Germany	2	5/2	2	5	2	2	3/2	5/3	2	2			
Russia	2	3/2	5/3	2	3/2	4/3	5/2	2	10				
Australia	2	3	2	2	10	2							
India	3/2	2	8	2	2	2	15						
Base Eight	2	2	2	2	2	2	2	2	2	2	2	2	2

The above table is a good illustration of what can be done by showing a part of the truth and not the whole truth. In the language of the courts we would like to have the whole truth and nothing but the truth.

Let here be presented another table (see opposite page) not prepared to convince us one way or the other about what number base should be used. It was prepared as an advertisement by the National Cash Register Company of Dayton, Ohio.

It will be noticed that although the names are varied the decimal or base ten is very conspicuous in the above table. It is almost universal in the money systems of the world. India's main coin seems to be the only one that strays from the decimal base.

If we take the paper money of the United States it is difficult to find the ratio 2 more prominent than 5 or 10. Why does the

[13] *Ibid.*, p. 507.

THE MONEY OF THE WORLD[14]

Showing the composition of the chief coin

United States	100 Cents equal 1 Dollar
Canada (British)	100 Cents equal 1 Dollar
United Kingdom	20 Shillings equal 1 Pound
France	100 Centimes equal 1 Franc
Germany	100 Reichspfennige equal 1 Reichsmark
Sweden	100 Öre equal 1 Krona
Norway	100 Øre equal 1 Krone
Denmark	100 Øre equal 1 Krone
Netherlands	100 Cents equal 1 Florin
Belgium	100 Centimes equal 1 Franc
Switzerland	100 Centimes equal 1 Franc
Italy	100 Centesimi equal 1 Lira
Spain	100 Centimos equal 1 Peseta
Austria	100 Groschen equal 1 Shilling
Soviet Union	100 Kopecks equal 1 Ruble
	10 Rubles equal 1 Chervonets
Czechoslovakia	100 Haleru equal 1 Koruna
Finland	100 Penniä equal 1 Markka
Greece	100 Lepta equal 1 Drachma
Hungary	100 Filler equal 1 Pengö
Turkey	40 Paras equal 1 Piastre
Argentina	100 Centavos equal 1 Peso
Brazil	1000 Reis equal 1 Milreis
Mexico	100 Centavos equal 1 Peso
Cuba	100 Centavos equal 1 Peso
Venezuela	100 Centimos equal 1 Bolivar
Uruguay	100 Centesimos equal 1 Peso
Chile	100 Centavos equal 1 Peso
Algeria	100 Centimes equal 1 Franc
India	16 Annas equal 1 Rupee
Japan	100 Sen equal 1 Yen

United States make paper money in 1-, 5-, 10-, 20-, 50-, and 100-dollar denominations if 5 and 10 ratios are difficult for the mind? Yes, there is the 2-dollar bill but we find people as a rule trying to get rid of them when they get them and there are not many of them left. Why are there not a series of 2-, 4-, 8-, and 16-dollar bills?

In conclusion let us try to answer the question, not what would have been the best base for our number system provided we had been faced with selecting one and not having one, but taking the world as it is today with its decimal system developed as it is, is it feasible, practical or possible to change the base of our number system?

There is no evidence for an affirmative answer to this question. The best that can be done is to compare what has been

[14] "The Money of the World," The National Cash Register Company, Dayton, Ohio.

attempted in a similar reform to the proposed reform. The reference is to the adoption of the metric system of weights and measures. All the metric system proposes to do is to change the value of our common weights and measures so that their intra- and inter-relations will be unitary or decimal. In other words, to make the relations within our weight and measuring system the same as within our natural number system with which the whole world is familiar. This is a reform that no one can deny is in the interest of simplicity for education, computation, business and commerce. Yet it has been very difficult to get this reform across to the whole world. Although about 80% of the world's population and all the leading countries except two have adopted the metric system and, although it is legal and used in scientific work throughout the world, there is yet a large force of inertia and conservative complacency that stand in the way of utilizing the full advantage of its universal usage.

Now when we think of changing the very base of our number system which took centuries to evolve and develop and change people's routine of quantitative thinking which they have carried on from a few years to a life time—that is a proposal which baffles the imagination and staggers our sensibilities. One would really have to be more of a practical psychologist than a mathematician in order to know human nature better than to suppose that such a drastic change could be possible.

To use the author's own words;

> Abstract numbers and arithmetic detached from things become only an empty game, as is chess, and of little practical value except as a mental exerciser.[15]

Is not a base eight number system an arithmetic detached from things?

All the discussions on number systems besides our own have their value. The chief one of these is a development of a mathematical appreciation which is so much underrated and neglected at the present time. Another value in these discussions lies in the material they furnish for the imagination. When we realize that more than one-half of the English books that are written and read are fiction rather than fact, there ought to be no objection to more books like *New Numbers* by Mr. Andrews. They belong to mathematical fiction and should have a place in mathematical literature.

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[15] *Ibid.*, p. 503

CASTING FUSIBLE METAL FOR TEACHING PHYSICAL CHANGE

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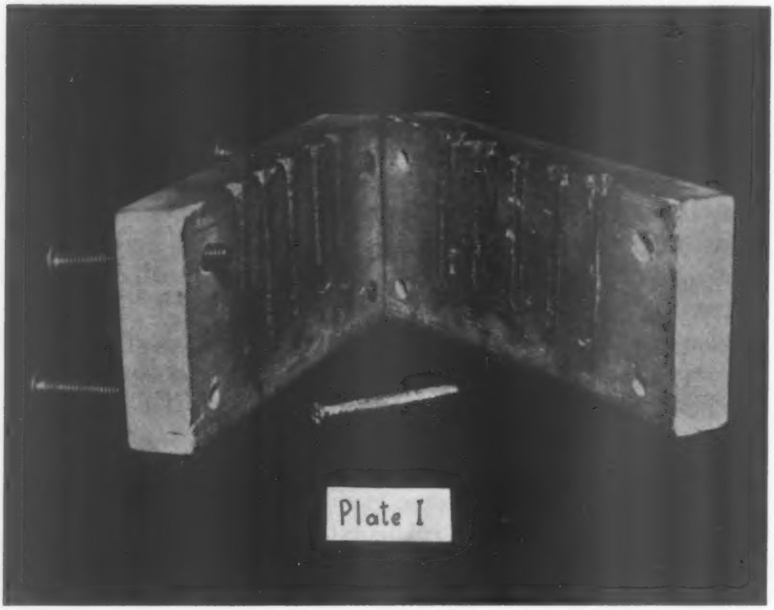
Central High School, Philadelphia, Pennsylvania

Fusible metals, such as Wood's alloy, enjoy wide acceptance as suitable material for illustrating "physical change" either as a demonstration by the teacher, or as a simple, safe and inexpensive student laboratory experiment. As commonly used in connection with "physical change," a small amount of the metal is introduced into some boiling water in a test tube. When the metal melts and is then chilled, to solidify it, the "button" takes on the shape of the bottom of the test tube, i.e., almost a hemisphere. At the close of the lesson the buttons of alloy are collected and held for use in the next class. A student in that next class is therefore given a piece of fusible metal which has almost the identical shape it will have when melted by him in an ordinary test tube. Most beginners in high school chemistry lack acute powers of observation and, because of the truly similar shape of the button before and after melting, such students wonder what the experiment attempts to prove, because nothing seems to them to have happened, even after the metal has melted. Some teachers who have used this material either as a demonstration or as a student experiment have probably wished that there were at hand some easy and convenient means of shaping it, so that its form at the outset would be very different from that of the hemisphere at the end of the experiment. Such teachers have probably invented their own methods of accomplishing this end. Perhaps they have already thought of and used one or more of the following methods. If not, they will find all of them satisfactory.

1. Casting "Nails" of Metal:

Two blocks of wood each six inches long by two and one-half high by three-quarters of an inch thick, are placed together and drilled in the manner shown in Plates I and IA. The ends of the holes are countersunk. The two blocks of wood are fastened together with four brass bolts, one at each corner. The metal is melted in a beaker and poured into all of the holes. No tendency to entrap air is noticeable. If the countersinking is wide and the "melt," just a few degrees above the melting point, is poured

into the hole, so as to fill it, entirely, a casting of pleasing appearance, resembling a nail, will result. If the mold is well made, the castings will be easily removed, otherwise it might become necessary to grease the holes with vaseline or other similar material. If the chemistry class is large and many castings are therefore needed, the mold may be a large one, with many holes. Otherwise a small mold must be filled several times, until enough castings are produced. Once such a mold is made it should last practically "forever." The only disadvantages of the casting



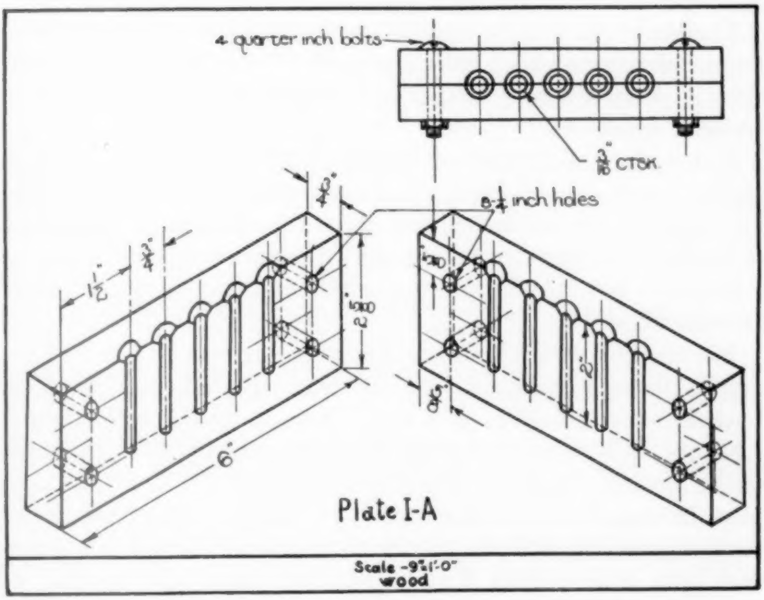
method just described are occasional difficulty in removing castings and the loss of time suffered when a small mold is used for a large number of castings.

2. Perforated Ladle:

Casting "nails" as described above involves either loss of time while waiting for the castings to cool before making another batch (necessitating also a reheating of the material for another casting) or the use of a very large mold. A second method was therefore tried. A sheet iron tray four inches long by two and one-half wide and one inch deep was prepared and a handle riveted on to one of the sides. Into the very edge formed by the bottom and one of the sides a series of one-sixteenth inch holes

was drilled, about one-half inch apart. The entire interior of the ladle was coated with "rouge."

Such a ladle is used in the following manner: The solid metal is placed in the ladle and the latter heated from the bottom. A smooth surface, such as a work-table top or a piece of sheet iron is held in readiness. When the metal begins to melt, tilting the ladle slightly downward on the unperforated side prevents the metal from running out. When the metal is entirely melted the ladle is brought to one side of the table or sheet iron, lowered



until the bottom almost touches the table upon which the metal is to be poured (while just enough tilt is maintained to prevent metal from running out) and then the ladle is both tipped over slightly on the perforated side and brushed straight across the table top. If this motion is executed properly a series of straight streams of metal will pour from the perforations and will soon cool into long thin sticks, which can be broken into several score of one inch pieces. After these pieces have been used in the laboratory by students, the teacher may gather them up and in one melt have a complete supply for use with the next class. Fifteen minutes should suffice for the entire operation. The rouge is used to prevent adhesion of the alloy to the ladle. When it wears away it is easily replaced. Success with this method is based

upon a minor skill which will be achieved by a little patience and practice.

3. Corrugated Paper Mold:

Simpler than either methods 1 or 2 is to melt the alloy down in a small beaker, and then to pour it into the grooves of a piece of corrugated paper held in readiness. Wooden blocks are placed on each side of the paper to close the ends of the grooves.

4. Fusible Metal Spoon:

Fusible metal may be used in the form of a teaspoon for class room demonstration of "physical change" and as a "magician's stunt." A satisfactory method for preparing such a spoon is to proceed as follows:

Cut a piece of cardboard of such a pattern and size, that it can be creased and folded into a tray or box eight inches long, four inches wide and two inches deep. Fasten the four corners of the folded box together with gummed paper or tape, so that the sides of the box may be lowered at will, and thus permit removal of contents of box.

Fill the box with Plastalene or modelling wax to one-half its depth. Press a teaspoon into the wax, so that the former is buried to one half of its thickness. There should be a distance of from one-half to one inch from any part of the spoon to the sides of the box. Press a pair of glass rods to one-half of their thickness into the wax, from the shoulder of the bowl of the spoon to the very edge of the box. Cover the exposed surfaces of the spoon and rods with a light coat of vaseline. Now pour plaster of Paris into the box until it is almost full. When the plaster has hardened, lower the sides of the box and remove contents. Pry the Plastalene away from the plaster cast and return cast and spoon in reverse position to that formerly occupied in the box. Now cover entire surface (spoon, rods, and plaster cast) with a light coat of vaseline and again fill the box with plaster of Paris. When hard, open box and remove rods and spoon very carefully.

Make a channel from the edge of the cast to the top of the spoon so that the final effect is a conical cut from edge of cast to top of spoon. The cut should be deep enough at the point where it touches the top of the spoon to allow free and easy passage of the melted metal. Examine openings left in the cast by the glass rods. These are for escape of air and should be perfectly unobstructed to the very edge of the mold, so that they

appear as two circular holes when the closed mold is examined from the top of the mold. The conical channel or gate should appear as a third circular hole when viewed from the top of the mold.

Soak a stick of wood in turpentine. Set fire to it and hold first the inside of one-half of the mold, then the inside of the other half, in the smoke of the burning turpentine, until the insides of both halves have become coated with a black film. The soot prevents adhesion of metal to mold.

Tie or wire the halves of the mold together very securely and pour molten metal into the gate. When cool, open, remove casting carefully and trim excess metal away. If the casting is removed carefully the mold may be used a dozen or more times. Such a teaspoon will "disappear" in a cup of hot tea to the great enjoyment of pupils and their unsuspecting elders. The metal may be removed from the tea-cup and of course cast again into the shape of a spoon.

PRUNING PINE TREES TO PRODUCE BOARDS ENTIRELY FREE OF KNOTS

Pruning young pines and other evergreen trees by a new "upside-down" method originated in Russia is expected to produce logs 20 or more feet in length yielding boards without knots. The new pruning method was originated by P. G. Krotkevich of the Kiev Forest Institute.

In the conventional pruning method, young trees are permitted to reach a certain height with relatively little attention. Then bottom branches are cut off, leaving a bunchy little top to develop to full size as the tree grows. This, however, leaves the bases of the young branches embedded in the heart of the tree, to become knots when the trunk is finally sawed into boards.

In the Krotkevich method, the young tree is permitted to develop a bushy growth near the ground, until it is about eight years old. After this, its central growth axis, or leader, is prevented from producing any more branches above this ground-hugging bush, simply by pinching off all side buds. The leader thus grows into a long, slender, pole-like sprout, deriving its nourishment from the bushy branches near the ground. Only after it has reached a height that will yield a log 18 or 20 feet long is it permitted to branch out and form a normal top. Growing in this way, it has no branch-bases embedded at the center, and hence will produce wholly knotless lumber.

The American commentators on the method feel that it is worth a trial in this country.

Rather than delay science one moment, let us urge society to catch up with it. Help to ennoble and not degrade the uses of science to a better life of the future.

—Dean MacQuigg.

A SCIENCE CLUB THAT HAD A FUTURE

CARROL C. HALL
*Springfield High School, Springfield, Illinois**

Out of the great State of Texas comes a story that has in it a challenge for every teacher of high school science. Particularly those teachers with science clubs. It is the story of a high school science club whose activities have influenced a whole section of a great agricultural area.

'Chemurgy' is a word packed with meaning for the farmers in Texas. The farmers of that state are looking for new crops to grow and for new uses for old crops. Their farm papers are filled with accounts of new developments in this field of agriculture. The great Southwest is experienceing a new adventure in pioneering. No wonder then that out of a rural high school comes this amazing story.

During the school year 1938–39 the School Science Club of White Oak High School located at Longview, Texas constructed a sweet potato dehydration press that is at the present time the backbone of a new Texas industry. Think of it! Not just another science-club project to demonstrate an established science fact or to amuse admiring fellow-students, but a functional, practical machine that solved a genuine commercial problem.

The development of this press enables the Texas farmers to raise profitably the sweet potato on a large scale. The press is an important unit in the process of converting the sweet potato into starch. The starch produced from the sweet potato is the aristocrat of textile starches. The sweet potato starch does a better job of penetrating the textile fibres than do other starches. It produces a stronger thread with less of the starch. It is essential in the production of very high grade sheeting and bag goods.

The starch has been found satisfactory in the manufacture of adhesives, confectionary goods, and in commercial laundries. Now that the starch can be produced more cheaply, due to the development of the dehydrator, industrial chemists are conducting research to find new uses for the starch in the manufacture of beverages, fireworks, vinegar, table syrups, pharmaceuticals, and cosmetics.

In time, the sweet potato starch will replace the sago and tap-

* Exchange Instructor in Chemistry, Hollywood (California) High School, 1940–41.

ioca starches that have been imported into this country for the uses just listed. Texas by the development of this new industry will become an important link in the development of our program of national self-sufficiency. This is an important factor in times of international stress.

The farmer further profits from the conversion of the sweet potato to starch. The potato pulp, after the starch has been washed out, is pressed and dried. This pulp is utilized as stock feed.

Now for the part played in the development of this industry by the White Oak High School Science Club—

The development of the commercially successful sweet potato dehydrator enables the processing plants to operate on a year-round basis rather than just during the sweet potato harvesting season. The dehydrated potatoes can be stored without danger of having them spoil. This insures the Texas farmer of a year-round supply of the dried pulp for stock feed and the manufacturer a constant supply of the starch for conversion purposes.

The machine developed in the White Oaks High School solved the problem of grinding the sweet potatoes in such a way that they will hold their starch during the processing. This was done by the development of a sawtooth drum rasp grinder that did the work more efficiently and cheaper than any previous method. The machine also incorporated a press for the removal of the moisture content of the potato.

The work with the sweet potato dehydrator soon outgrew the high school environment and was transferred to the chemistry department of the North Texas State Teachers College at Denton. Here a semi-commercial model of the plant was constructed. Demonstrations were given throughout the East Texas country and much interest in the sweet potato starch industry was stimulated. Consequently three experimental commercial plants have gone into operation and a new industry for Texas looms on the horizon.

Behind all this activity stands the figure of Gilbert C. Wilson, the White Oaks High School science teacher. It was his driving energy, vision, and long hours of thought and labor that transferred an idea into reality. Today, Wilson is a member of the faculty at North Texas State Teachers College and is a teacher of farm industrial chemistry. Needless to say that school is continuing its research program in the chemurgical uses of the sweet potato and other plants native to Texas.

SOME SIMPLE NUMERICAL RELATIONS OF OUR COMMON WEIGHTS AND MEASURES

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There are some remarkably simple relationships to be found in our common system of weights and measures that do not seem to have found their way into our textbooks of science and mathematics. Their recognition can be used to make our classroom work both interesting and practical.

When the metric system was established a unit of weight was desired. This unit was arrived at by using a tank that had a capacity of exactly one cubic decimeter and having it filled with rain water that was cooled to the temperature at which its density was greatest (4°C.). This weight of water was divided into 1000 equal parts; one of these parts was used as the unit of weight and given the name of "gram." The method thus used to secure a unit of weight has been given great scientific praise and referred to as "a stroke of scientific genius." Yet identically the same method had been used half-a-thousand years earlier with a cubic foot tank to secure the weight of the ounce—and this fact has been given too little recognition.[1] A somewhat similar, but less simple plan, had been used in the connection with the volume to be given to the gallon—and this, too, has missed general recognition.

The relations between the foot, ounce, pound and gallon can be briefly summarized as follows.

For water at 4°C., the temperature at which its density is at a maximum—

1 cubic foot	=	1000 ounces
16 cubic feet	=	1000 pounds
32 cubic feet	=	1 ton
12 gallons	=	100 pounds
3 quarts	=	100 ounces
30 quarts	=	1 cubic foot

These are not rough values. All are accurate to within 4/100 of one per cent. The extremely small error that does exist came, apparently, as the result of a very slight change in the weight of

[1] It had also been used by the Egyptians and the Romans, as is explained in an article by the author that appeared in SCHOOL SCIENCE AND MATHEMATICS, 39: 126–32 (Feb. 1939).

the pound made in the time of Queen Elizabeth; this change was to make the pound exactly equal to 7000 troy grains.

It has been emphasized over and over in the science books that the values of density as expressed in metric units are definitely superior to the corresponding values expressed in common units in that they make specific gravity tables unnecessary. Yet the weight in grams of a cubic decimeter (or liter) of a substance is numerically the same as the weight in ounces of a cubic foot of the substance. Whatever advantage one plan would possess would be found in the other plan. As examples of the two ways of expressing density, mercury and hydrogen may be chosen as the substances. A cubic decimeter, or liter, of mercury has at 0°C. a weight of 13,600 grams; a cubic foot has a weight of 13,600 ounces. A liter of hydrogen measured under standard conditions has a weight of 0.09 grams; a cubic foot has a weight of 0.09 ounces.

In the science classes some of the relations that have been mentioned can be used, to advantage, in connection with the presentation of the topic of water pressure due to depth. The following material summarizes the relationships that may be used.

Depth of water	Pressure at a temperature of 4°C.
1 foot	1000 ounces per square foot
16 feet	1000 pounds per square foot
32 feet	1 ton per square foot
23.04 feet (approx. 23 ft.)	10 pounds per square inch
$27\frac{2}{3}$ inches	1 pound per square inch

Water expands upon heating. At 20°C. (68°F) each pressure is $\frac{1}{5}$ of one per cent less than that given. Unless great accuracy is desired the correction can be ignored.

The relationships between length, volume and weight can also be used in connection with air pressure. The average air pressure at sea level is commonly considered as being equal to that of a barometer reading of 30 inches of mercury. According to Weather Bureau records the average air pressure varies with the season of the year. It also varies somewhat with the latitude. For a latitude of 50° N the annual average is reported as 29.95 inches. For 45° N the average is 29.98 inches and 30.00 inches for 40° N. These readings are for a barometer in which the mercury

has a temperature of 0°C. At that temperature mercury has a density of 13,600 ounces per cubic foot.

For an air pressure equal to 30 inches of mercury the following simple relationships exist.

30 inches of mercury = 34 feet of water
Pressure per square foot
= 34,000 ounces or
2125 pounds or
1 1/16 tons
Pressure per square inch
= 14.7 pounds
Upon every 7 square inches the pressure
is very nearly equal to 100 pounds

As may be judged by the relationships that have been pointed out the common system of weights and measures offers wide possibilities of use in our science classes. Since the fundamental units in that system will be used over and over by the student in his adult life an emphasis placed upon the simple relationships between those units should make our science teaching both interesting and practical.

REMAGNETIZING OLD COMPASSES

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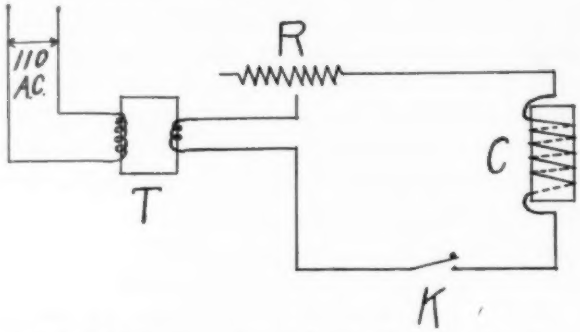
In nearly every laboratory many of the small 10 mm. compasses are found with their poles reversed. This occurs in some of the larger compasses as well if students abuse them during laboratory periods. The object of this article is to pass on to other teachers the method I have found to be most satisfactory in reconditioning compasses.

Wind about one hundred turns of No. 29 or No. 30 insulated copper wire on a piece of cardboard mailing tube that is approximately $1\frac{1}{2}$ inches in diameter and 3 inches in length. Connect this coil in series with a rheostat to the secondary of a step-down transformer that provides 10 or 20 volts. As indicated in the diagram, T is the transformer, R the rheostat, C the coil, and K the switch that has been added as a matter of convenience for the operator.

To demagnetize the compass, insert it in coil C, close the

switch *K*, and remove the compass a few seconds later while the current is still flowing through the coil. The compass is now demagnetized. Open the switch. In order to magnetize the compass insert it again in coil C, close the switch and leave the compass in the coil until the current is turned off. The compass is now magnetized and ready for use.



CIRCUIT FOR MAGNETIZING AND DEMAGNETIZING COMPASSES

Larger compasses may be reconditioned in the same manner if large size coils are made in the beginning. If a transformer is not available to step down the 110 A.C., set up a water resistance in series with the coil *C* and the switch *K*. A glass battery jar about one-half full of water and provided with two pieces of metal to serve as terminals is suitable. Add just a little of some electrolyte such as table salt, baking soda, or a few cubic centimeters of sulfuric acid to the water. More may be added later if more current is needed. If too much current is flowing and the coil heats rapidly raise one of the terminals slightly. This device, or jar, may be used with coil *C* as indicated above on the ordinary 110 A.C. circuit.

In addition to the use of this circuit for reconditioning compasses, it provides a means of demonstrating the principle used by the jeweler in the demagnetization of a watch.

EXPEDITION TO COLLECT BIRDS IN MEXICO

Plans for a Cornell University-Carleton College ornithological expedition into Mexico in 1941 have just been announced.

The leader will be Dr. George M. Sutton, curator of birds at Cornell, and Dr. C. S. Pettingill, zoology instructor at Carleton.

The expedition will be gone from February to June, 1941, during the Mexican birds' breeding season, and will be based at Rancho Rinconada, in southwestern Tamaulipas. Work will be mainly in that state and in San Luis Potosi, Vera Cruz and Hidalgo.

FORMULAS FOR VOLUME BY SIMPLE ALGEBRA

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The formulas for the volume of the solids occurring in solid geometry texts may all be regarded as special cases of Simpson's One-Third Rule. This rule can readily be obtained without a knowledge of calculus. Further only a knowledge of plane geometry is required to show that for the various figures of solid geometry the limiting value of the sum as given by Simpson's Rule is in reality the desired volume. We assume here then a knowledge of plane geometry. Next we state the formulas for the following sums.

$$(1) \qquad 1+2+3+\cdots+n=\frac{n(n+1)}{2}\cdot$$

$$(2) \qquad 1^2+2^2+3^2+\cdots+n^2=\frac{n(n+1)(2n+1)}{6}\cdot$$

$$(3) \qquad 1^3+2^3+3^3+\cdots+n^3=\left[\frac{n(n+1)}{2}\right]^2.$$

These are readily proved by induction.

Consider now a solid figure; such as a cone, a carrot, a piece of cheese, a potato, or a loaf of bread cut into n slices by $(n+1)$ parallel planes equally distant apart, say h apart. The volume of any slice is approximately equal to its upper cross-sectional area times its thickness, h. In order to include the volumes of all the figures ocurring in simple applications we assume that the area of any cross section may be expressed by the cubic

$$(4) \qquad f(x)=a_0+a_1x+a_2x^2+a_3x^3$$

where x is the distance to the $(r+1)$th cutting plane measured from some fixed plane which is parallel to the cutting planes. Let

$$(5) \qquad x=x_0+rh.$$

Then $x=x_0$ corresponds to the first of the $(n+1)$ cutting planes, or to the lower base, $x=x_0+h$ to the second cutting plane and $x=x_0+rh$ to the $(r+1)$th cutting plane. The volume of the first slice will be equal approximately to its upper cross-sectional area times its thickness or equal to

(6) $f(x_0+h)h=[a_0+a_1(x_0+h)+a_2(x_0+h)^2+a_3(x_0+h)^3]h.$

Similarly the volume of the rth slice is equal approximately to

(7) $f(x_0+rh)h=[a_0+a_1(x_0+rh)+a_2(x_0+rh)^2+a_3(x_0+rh)^3]h.$

The volume of the entire solid is approximately equal to the sum of the approximate volumes of the n slices. Further as the number of slices increases the differences between the true volume and this approximation obviously decreases and approaches zero as a limit.

The mathematical problem is then to find the sum of these n approximate volumes and then to find the limit of this sum as n increases without limit. This problem is readily handled by calculus. Also in one form or another it is treated in solid geometry. It is the purpose of this paper to solve the problem using only the simplest of algebra. After multiplying out and collecting terms equation (7) may be written in the form

$$
\begin{aligned}
f(x_0+rh)h &= (a_0+a_1x_0+a_2x_0^2+a_3x_0^3)h \\
&\quad +(a_1+2a_2x_0+3a_3x_0^2)h^2r \\
&\quad +(a_2+3a_3x_0)h^3r^2 \\
&\quad +(a_3)h^4r^3.
\end{aligned} \tag{8}
$$

This is the approximate volume of the rth slice and our problem is to find the sum of the approximate volumes of the n slices. Setting $r=1, 2, \ldots n$, in equation (8) and writing out in detail gives n expressions similar to (8). Adding these vertically by means of equations (1), (2), and (3) gives for the approximate sum, S_n, of the n slices the expression

$$
\begin{aligned}
S_n &= (a_0+a_1x_0+a_2x_0^2+a_3x_0^3)hn \\
&\quad +(a_1+2a_2x_0+3a_3x_0^2)h^2\,\frac{n(n+1)}{2} \\
&\quad +(a_2+3a_3x_0)h^3\,\frac{n(n+1)(2n+1)}{6} \\
&\quad +(a_3)h^4\left[\frac{n(n+1)}{2}\right]^2.
\end{aligned} \tag{9}
$$

To find the limit of this sum, S, as n increases without limit assume the height to be $2H$ so that

$$nh=2H. \tag{10}$$

Then the expression for S_n becomes after replacing hn by its equal $2H$

$$
\begin{aligned}
S_n = {} & (a_0+a_1x_0+a_2x_0^2+a_3x_0^3)2H \\
& +(a_1+2a_2x_0+3a_3x_0^2)\left(\frac{4H^2}{2}+\frac{h2H}{2}\right) \\
& +(a_2+3a_3x_0)\left(\frac{16H^3}{6}+\frac{h12H^2}{6}+\frac{h^2 2H}{6}\right) \\
& +(a_3)\left(\frac{4H^2}{2}+\frac{h2H}{2}\right)^2. \qquad (11)
\end{aligned}
$$

Finally we note that as the number of slices increases the thickness of each, h decreases so that in the limit h becomes equal to zero but nh always equals $2H$. Consequently the terms in equation (11) involving h approach zero as n increases. Hence the limiting value of the sum, S, is

$$
\begin{aligned}
S = {} & (a_0+a_1x_0+a_2x_0^2+a_3x_0^3)2H \\
& +(a_1+2a_2x_0+3a_3x_0^2)2H^2 \\
& +(a_2+3a_3x_0)\frac{8H^3}{3} \qquad (12) \\
& +(a_3)4H^4.
\end{aligned}
$$

Here we assumed the height of the figure equal to $2H$. Rearranging the terms of equation (12) shows that the cross sections of the figure actually used in the formula for its volume are the upper and lower bases and the mid-section. The formula for the volume being

$$
S=\frac{2H}{6}\left[f(x_0)+4f(x_0+H)+f(x_0+2H)\right]. \qquad (13)
$$

This is Simpson's One-Third Rule. It is also the prismatoid formula of solid geometry. The derivation given here shows that it is of far greater application than the solid geometry derivation of it would indicate.

If we assumed the height of the figure equal to $3H$, that is, if we let

$$
nh=3H \qquad (14)
$$

then a similar argument and rearrangement of terms leads to Simpson's Three-Eighths Rule

$$(15) \qquad S=\frac{3H}{8}\left[f(x_0)+3f(x_0+H)+3f(x_0+2H)+f(x_0+3H)\right].$$

Here we need to know the area of four equally distant cross sections.

It is natural to ask if the number of cross sections whose area is required can be reduced to two. The answer is yes. By matching the terms given in equation (12) against those represented by the expression

$$(16) \qquad S=H\left[rf(x_0+m)+sf(x_0+n)\right]$$

we obtain the following system of equations for determining the arbitrary constants, r, s, m, and n

$$(17) \qquad \begin{cases} r+s=2 \\ rm+sn=2H \\ rm^2+sn^2=\dfrac{8}{3}H^2 \\ rm^3+sn^3=4H^3. \end{cases}$$

One solution of this system is

$$(18) \qquad \begin{cases} r=s=1 \\ m=\left(1-\dfrac{\sqrt{3}}{3}\right)H \\ n=\left(1+\dfrac{\sqrt{3}}{3}\right)H \end{cases}$$

whence the formula for S may be written in the form

$$(19) \qquad S=H\left[f\left(x_0+\left(1-\frac{\sqrt{3}}{3}\right)H\right)+f\left(x_0+\left(1+\frac{\sqrt{3}}{3}\right)H\right)\right]$$

where the height equals $2H$.

It is to be noted that all the formulas given are exact for any solid whose cross-sectional area is a function of the third degree or less of the distance from some fixed plane parallel to the cutting planes. For more complicated figures these formulas usually give good approximations to the true volume. Taking the cutting planes closer together, of course, increases the accuracy of the approximation.

Simpson's One-Third Rule is the more popular of the formu-

las given. As an illustration of its use, suppose it is required to find the volume common to two equal right cylinders of radius a which intersect at right angles. Taking the upper and lower cutting planes as just tangent to the cylinders and the middle section as the plane containing the axes of the two cylinders, it is readily seen that the area of the upper and lower bases are zero and that of the middle section is $4a^2$. Further the area of any section parallel to the middle section and a distance x from it is equal to $4(a^2-x^2)$. This is a function of the second degree in x so that our formula will give the exact volume. The height of the common volume is $2a$.
Substituting in equation (13) gives

$$S=\frac{2a}{6}\left[0+4.4a^2+0\right]=\frac{16a^3}{3}\cdot \tag{20}$$

Due to the lack of space the writer has not developed here the various special cases, such as, the formula for the volume of a pyramid, a cone, a sphere, a segment of a sphere, the frustum of a cone, etc. The usual formulas for these are all readily obtained from Simpson's One-Third Rule.

The method given here was developed to meet the needs of a class in applied mathematics who had had no calculus, no solid geometry, and no trigonometry or college algebra. The author can assure anyone interested that this method when presented in detail can be readily grasped by such students. All the formulas of solid geometry can be obtained in two class periods. However, many students prefer to rely solely on Simpon's Rule and to adjust it to the problem in hand.

PRODUCTIVE WORK A NECESSARY ELEMENT OF EDUCATION

The school can introduce productive work without wages into its program in accordance with thoroughly legitimate educational principles if it convinces young people that it is their duty to contribute to community welfare. . . . Schools can also put their pupils in contact with opportunities that give practical work training and prepare more directly than does ordinary school work for later employment by arranging with industries to give pupils part-time employment. . . . Those who are to enter the professions need to labor at some period in their lives in order to gain an understanding and appreciation of what labor is. Those who are going to earn their living by labor have a right to be trained under competent supervision so that they may enter on their careers under the most favorable conditions possible.—*Excerpt from a report of the Committee on the Secondary School Curriculum of the American Youth Commission.*

HUMANIZING THE PHYSICAL SCIENCE TERM REPORT

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Every teacher of high school chemistry or physics is probably conscious that these courses contain fundamental principles and important everyday life implications which get less emphasis than they deserve. The wealth of facts to be mastered constitute one limiting factor in the achieving of this broader type of objective. The student attempts to master a large amount of new factual material but often times he is not able to get many new ideas with wide enough everyday significance to be of living interpretative value to him. At Pasadena Junior College the eleventh year physical science course aims primarily at these more general outcomes and emphasizes the impact and influence upon human affairs of developments in the fields of chemistry, physics, mathematics, geology and astronomy.

Among the more than 650 students enrolled in this course are to be found all of the types and grades of ability common to eleventh year students. The usual variety of educational plans and programs for the future are also represented. Manifestly the course cannot be classed as a consumer-science type for only non-science major students. Instead it fills a very definite function of orientation in the field of the physical sciences for all eleventh year students who in the 6–4–4 plan are at the beginning of their four year upper grade educational experience. At the same time it is accredited by the University of California as equivalent to high school physics and chemistry both for entrance and for Junior Certificate Standing.

It should be pointed out that science majors and others whose courses require credits in both chemistry and physics have no difficulty in completing the equivalent of these two courses in two years. Such students in their twelfth year supplement the physical science course by a semester each of a special chemistry and a special physics course. These semester courses are designed to fit onto the eleventh year course. It should be emphasized in passing, that there is ample evidence to show that students taking these two years of the newer courses equal and exceed the achievement of students who have taken the traditional high school chemistry and physics. As will appear later, it

is believed that these newer courses give certain valuable educational outcomes which the traditional courses can scarcely be expected to achieve.

The question naturally arises as to how this new, five year old physical science course is different from the usual high school chemistry and physics. As in these latter courses, the basic facts, principles, theories and laws in these sciences as well as in geology and astronomy are presented. Less emphasis is placed however on the learning of such material and considerably more emphasis is put upon the influences and significance of the physical sciences in human affairs. By this change in emphasis it is possible to become more familiar with the methods by which scientific facts, laws and principles are developed. Constant stress is placed on the reasons why such scientific methods produce results and on their applicability to the everyday life of everyone.

Of equal importance and emphasis is the understanding of the impacts which science, scientists, and their methods have made upon human life and activity in the past and present. Striking illustrations of how Ptolemaic versus Copernican theory, Aristotle's versus Galileo's methods of study, or of alchemist versus Roger Bacon-Robert Boyle procedures have ultimately revolutionized cultures, habits of thought, and civilization itself, are shown to have an educational contribution to make to anyone who is to try to understand our modern complex existence and to do his part as an active, intelligent citizen. The possibility is considered that present day fumbling and groping with economic and social problems may be due at least in part to the fact that too little or no emphasis was put in the education of the present adult generation, upon man's development of power and power machines, methods of rapid communication and transportation, and new materials involving world wide commerce, and upon the economic and social changes which followed.

Methods for giving such an emphasis to a science course will vary and necessarily will be influenced by such factors as class size, teacher load, and teaching facilities. In the Pasadena physical science course a compromise with teaching cost has led to setting up a weekly program of four somewhat different types of student experience. Two days per week each student is in a lecture group numbering up to 108 students. Visual methods of all kinds are emphasized here with demonstrations, slides, moving pictures and sound films. The other three days in the week this group of 108 is divided into three groups of 36 each. Each group

has during these three days a laboratory, a discussion, and a reading period.

Effort is constantly made to prevent this apparently formal weekly schedule of activities from producing formal methods and routine educational results. It is felt that one worthwhile activity which is important in developing desirable outcomes is to be found in the term report required during each student's last semester. Here is one of the places where individualizing and personalizing of instruction can and does take place. It necessarily must occur if the eleventh year student is to reach the outcomes set up for the course and for this semester project. This is true because scarcely any student up to this time in his education has attempted to think and to interpret his ideas toward the outcomes set up for this piece of work.

Quoting from directions for student activities in the last unit of the text *Our Physical World** prepared for this course the student is told: "After several months of study you should have gained an understanding of some of the important principles of science and their place in the development of civilization. You have doubtless also formed some opinions about the place of science in the important problems of the day. These opinions may differ from those of your classmates or instructor, but if you have facts which apparently support them, they deserve consideration.

"In completing this last unit in physical science, you should prepare a paper on some aspect of science which affects an economic, political, or social problem. . . . If you are interested in the promotion of world peace, you could make a study of the methods by which science might be used in the interests of peace rather than war. The purpose of this paper is to give you the opportunity to develop a new idea which has resulted from this course, not merely to report on your reading."

The date for reporting a tentative subject for the report is set early in the first semester. In spite of previous explanations and discussion as to what is desired, almost invariably such subjects as the following are handed in at first:—

A History of Radio, *The Life of Edison*, or *Artificial Refrigeration*.

Obviously it is necessary for the teacher to individualize his comments on such traditional topics. The student must be helped to see that his report will only be satisfactory in the de-

* Eckels, C. F., Shaver, C. B., Howard, B. W. *Our Physical World*. Benj. H. Sanborn & Company.

gree in which he uses such a topic to give his own thinking and conclusions with respect to its importance, influence or potentiality in human affairs and life about him. Discussion can bring out that *Our Radio-Influenced World* or *Edison's Indirect Influences on My Life*, or *How Refrigeration Can Change Food Habits*, are title statements which suggest the desired point of view. Emphasis is placed on the fact that reading can only supply the material for thinking in this report. Thinking in terms of the human influence, social impact or economic result is the process which is desired.

Not every eleventh year student will get the desired viewpoint unless endless time is available for personal consultations. The great majority however do get the idea after one or two conferences or detailed written comments on tentative topics or outlines have been made. It is interesting to note that the grasping of the new viewpoint for a report seems to develop a new and fresh interest on the part of nearly every student in writing the term paper. It is probably because opportunity is afforded to form and to express his own opinion, an activity which is enjoyed more or less by most human beings, but which is too often limited in many school courses.

Originality in form and method of presentation is encouraged and is willingly adopted in many reports. Illustrations from magazines, advertising pamphlets and similar sources are effectively used by some students. Some turn in cards on which samples or examples are mounted. Satisfactory final results are usually closely correlated with the setting up of a definite time schedule for handing in such progress reports as *Tentative Topic*, *Preliminary Outline*, *Final Outline*, etc. The preliminary outline is usually the place where the teacher makes the most careful and detailed comments and suggestions to develop the desired attitude and viewpoint in the mind of the student.

The idea of a term report is certainly not new. For eleventh year students however it is something of a new experience to select from their year's work in physical science a topic or area in which to attempt to show their own idea of what its importance has been, now is, or may be in social or economic affairs. The extent to which this human influence point of view has been developed throughout the year is seen in the readiness with which the student "gets the idea." It is only when a course is freed from the traditional subject matter mastery and mathematical problem-solving necessity that some of the more intan-

gible but humanly significant objectives can properly be emphasized.

During the entire year's work at every opportunity such a viewpoint of the significance and potentiality of the physical sciences has been emphasized in lectures, laboratory, reading and discussion periods. Students have been encouraged to think in these directions. Some do not seem to mature sufficiently to evidence much growth in ability to make such interpretations. But taken as a group the large majority show an increasing ability to see the results of science in their everydy life. They begin to see some of the problems which have arisen from the incomplete or unbalanced applications of inventions and practical developments of science. Often times this somewhat new experience of seeking to interpret life in terms of facts learned in science has a very noticeable maturing effect on the personality of the student.

One of the purposes of this sort of final semester report is to draw together and capitalize the results of these new viewpoints and attitudes. In many cases surprisingly mature results come from the student's serious effort to do his own thinking and to express his own thoughts and conclusions. It is believed that some of this interpretative viewpoint toward everyday problems, where something of the scientific attitude and method is applied will continue along through life with the student as a highly desirable educational acquisition. Certainly it has a somewhat better chance for survival than has the remembering of a wealth of facts, important though they may be in chemistry and physics.

TEACHING KIT OF AVIATION AIDS

The United Air Lines Transport Corporation has prepared a valuable teaching kit of helps for teachers and students of aviation. It consists of the following:

1. A manual of teaching helps from aviation to enrich the study of history, geography, civics, English, science, etc.
2. Twelve printed pictures of planes and air travel ($11'' \times 13\frac{3}{4}''$) for use in class and later for hanging in the school room.
3. An aviation wall map ($20'' \times 24''$) and colorful poster material for classroom decoration.
4. Forty printed pieces ($8'' \times 10''$) for free distribution to the students to take home. These pieces have a small map on one side of the sheet, and the new Douglas DC-4 Super Mainliner on the other.
5. Suggested uses of all materials in the kit.

These kits may be obtained for ten cents each from The United Air Lines, 5959 S. Cicero Avenue, Chicago, Ill.

AN IMPROVED SEQUENCE IN PHYSICS

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Not so many years ago it was standard practice for physics majors in college to study a year of general physics, and to follow that by a second and sometimes a third year of general physics before specializing. With the increase in importance of the various special fields, this practice has almost vanished; yet there were very valid reasons for the arrangement. Most important, perhaps, was the return to familiar fields during the second and third years with new knowledge, new tools, sharpened appetites and interest. The educational process finds its full fruition in the recognition of relatedness of adjacent fields of study. The student finds the fullest satisfaction when he discovers, for himself, that something studied in another room, or in another year, has an immediate and important bearing on something now before him.

During the past year we have carried out a program of secondary school physics which has succeeded in realizing some of the advantages suggested above, doing this in a course of a year's duration, while still conforming to requirements for admission to college. In the process, we find that, even in the first year of the new program, when there are roughnesses still to be eliminated, when there is much creaking of the machinery and considerable improvising, our results, measured by such external standards as are available, seem to surpass those of previous years following a more conventional program. Oddly enough, the most marked advantage of the arrangement was not the primary motive in setting up the new order.

Inequalities in difficulty in the old order were probably most instrumental in bringing about the change. Students were found to flounder so badly in parts of mechanics that they were discouraged almost to the point of dropping the subject. Later they found parts of sound and light so easy that they developed a false sense of security. Furthermore, interim marks given after a severe or an easy section failed to evaluate the true worth of the student. In general, faculty and students alike had begun to wonder if there was any reliability or continuity to the marks we gave in physics.

Accordingly, we set to work to plan an order of progress

through the various fields of physics, arranged in gradually increasing difficulty. It was our aim to develop skills and methods of thinking and working while dealing with simpler concepts, then to use these in the next stage while developing from them further skills and abilities. We believed that any difficulty brought about by changing frequently from one major field of physics to another would be compensated, and more, by the advantages of the gradual growth of difficulty and the ability to cope with it.

As the plan took shape in our minds and on paper, it soon appeared that certain misgivings we had had were entirely without foundation. For example, the transition from one branch to another appeared to become easy and smooth, once the plan was worked out. Later on in practice, these transitions proved to be a positive gain, one of the great merits of the system.

There is no reason to suppose that this arrangement is the only one which can succeed. Many decisions were made on the slimmest sort of evidence or conviction. As the plan grew, it appeared that much of the later progress was determined by a few of the earlier decisions. In many cases we decided to follow a certain line merely because it appealed to us at the moment. If we were planning such a program again, after a different background of experience and actuated by slightly different motives, it is probable that a new order would develop, equally or perhaps more successful in practice. The one and only absolute requirement is an open mind, a willingness to relinquish certain procedures that were considered essential, in order to give a full and complete trial to the new style.

For a few years prior to the inception of this plan, our colleague, J. C. Hogg, teaching a two year sequence in physical science, had started the course with hydrostatics and heat, as the part of physics most fundamental to a study of chemistry. In order to simplify the problems of handling apparatus, we had tried the same order for beginning a one year study of physics. Since this approach had proved fairly satisfactory and seemed to fit in with the underlying ideas and ideals of our program, we have retained that beginning, with slight modification. In the program which is given now in detail, before we attempt a discussion of its merits, we have made one or two minor corrections based on the experience of this year, so that the program given is that which we plan to follow in 1940–1941.

Matter. Weight. Density and Specific Gravity. Units of Measurement. Moment of Force. Weighing.
Three States of Matter. Properties of Solids. Elasticity, etc.
Liquids. Pressure, Buoyancy.
Gases. Atmosphere. Barometer. Compressibility.
Molecular Theory and Phenomena.
Heating and Expansion. Gases. Thermometry.
Calorimetry and Change of State. Vapors.
Transfer of Heat. Radiation.
Heat Radiation and Light. Reflection. Refraction. Geometrical Optics. Wave Theory as Needed to Explain Refraction. Instruments.
Electric Heating and Lighting. Currents. Effects of Current. Electrostatic Forces. Potential. Ohm's Law.
Magnetism and Electromagnetism. Motor and Generator.
Simple Machines and Work. Mechanical Advantage. Power. Efficiency.
Components on the Inclined Plane
Accelerated Motion. Force and Motion. Energy.
Extension of Energy to Other Fields. Energy of Liquids.
Electrical Power and Energy. Motor and Generator.
Heat and Mechanical Energy. Conversion Factors.
Kinetic Theory of Heat. Molecular Phenomena and Energy. Boyle's and Charles' Laws. Evaporation and Vapor Pressure. Refrigeration. Liquid Air.
Sound (Transmission of Energy by Waves)
Wave Theory of Light. Color. Spectra. Interference.
Equilibrium. Moments. Resolution and Composition of Forces.
Electrostatic Induction. Condenser. Electrolysis. Alternating Currents.
Modern Physics. Electronics.

It was evident from the start that transitions from one field to another must be justified and made plausible by a linkage of the two adjacent topics. At first it appeared to us that in some cases the linkage might be more apparent than real. We set out to establish the connection by occasional reference to things to come and by suggestions that present studies would be more significant in the light of further knowledge and deeper understanding. Most fundamentally, we tried to use the knowledge and experience of the average student as a jumping off place for our excursions, using as a motivating force his natural curiosity to explore regions just beyond his horizon. As the knowledge and understanding of the students increased, as the horizon of knowledge ever widened and the realms nearest and ready for understanding increased in size, we continued our explorations, always over ground that lay nearest, and over regions already glimpsed from afar. As a student's knowledge and understanding expand, there must always be, at any point in education, certain fields of knowledge which are readiest for apprehending, as fruit is ripe for the plucking at a certain season. It was ever our aim to find these fields which can be learned with least effort, to turn our attention to them while getting a glimpse of

the next field, and the next. It was never our idea that a topic, once started, should be covered completely. In fact, it could not be, since any topic is fully understood only when it is seen in its relation to other fields. On the other hand, it was vitally necessary for the morale of the students, if for no other reason, that any topic, once undertaken seriously, be dealt with in sufficient detail and with such examples and illustrations, numerical and otherwise, that the student felt confidence in his grasp of the subject, and confidence in his instructor and the general handling of the course.

The introduction to the subject through the general properties of matter is obvious enough. Weight and density are introduced first. From them arises the need for measurement and the units of measurement. The moment of a force comes in naturally in connection with weighing, but the detailed study of equilibrium is postponed almost to the end of the course. After weighing with a platform balance, the spring balance leads to a demand for Hook's Law and elasticity. The elastic limit and other properties such as malleability lead to a discussion of the various states of matter. Thus we embark on a detailed study of the properties of liquids. The study of gases ends with Boyle's Law and the restriction that the temperature shall remain constant. The students naturally ask what would happen if the temperature did not remain constant, and we find ourselves engaged in a study of heat. In this field it is simple enough to bring in the idea of molecules and molecular motions, postponing the fuller proof of the concept to a later time. It is possible to show simply vaporization and vapor pressure in its relation to molecular theory. Last in heat comes a study of the modes of transfer. Radiation, the last of these, is somewhat mysterious and challenging. We decide to find out more about it by a study of light. Though we do not, at this time, seek to prove the wave theory, the idea may well be used to clinch the law of refraction.

Having seen various forms of electric lights, the students are keen to know more about them. Accordingly, we give them a brief introduction to current electricity, with Ohm's Law and the concept of potential and resistance. We did not, last year, introduce any electrostatics at this time, and rather felt the lack. Next year we plan to take up the law of force, to give reality to the driving force of electric potential. Induction and the condenser are left till later. Magnetism and electromagnetism lead into the generator and motor—just a glimpse. The need is dis-

covered for a better understanding of mechanics. What is the meaning of work and power? What is the relation between force and motion? So we are back in mechanics, which is done thoroughly, with better understanding in January and February than we have ever found in October and November. Even so, equilibrium is left till later, machines being treated as cases of motion, doing work. Components, introduced quite naturally in connection with the inclined plane and used again with velocities, pave the way for the later study of the crane.

When we have grasped the idea of energy, kinetic and potential, and other forms, we are ready for a general review of all that has gone before, viewed now in its relation to this new and all inclusive concept. Energy in molecular motions, energy in liquids, conversion of heat to mechanical energy or the reverse, conversions between electrical and mechanical forms, all are considered together. Here we require, naturally, more intensive studies in certain fields; notably, liquids in motion, motors and generators, refrigeration, and molecular phenomena.

Sound, an example of the transmission of energy by wave-motion, leads us into the wave theory of light, together with color and spectra. The return to light is made the occasion for another general review. Equilibrium, coming next, naturally recalls parts of mechanics studied earlier. A laboratory experiment on moments involves a determination of specific gravity by Archimedes' Principle.

Some features of atomic electricity, together with the condenser and alternating currents, complete the program. Thus the student is brought to the end of the year, having touched on almost all topics more than once, having gained confidence and familiarily with the return to old friends. And it is the more useful in that the old friends are seen in the light of new knowledge and increased understanding. The relation of each part of the subject to other parts is clearly seen, and its relation to the student's experience makes the study all the more real and interesting. Furthermore, through the process of enlarging the student's experience as he goes forward through the course, it is rarely necessary to study in detail an idea that is wholly new. Each topic to be dealt with is introduced early to induce familiarity. Later it is brought out again and studied in as much detail as possible without an attack of mental indigestion. Then it is left for a process of gradual assimilation while other new topics are dealt with in similar fashion. Finally, it is viewed in rela-

tion to other knowledge and experience subsequently acquired.

From the results of a single trial, with eighty students in six different sections, we are convinced that this approach is highly successful. The reaction of the students, judged subjectively, has been remarkably favorable. Their interest has been good at all times. Students who were becoming discouraged by the rigorous analysis of one part found a new interest and enthusiasm when we changed to another topic. Though there were times during the year when they seemed not quite so confident as might be desired, in the end their understanding appeared quite as good as it has ever been for such a group. In addition, they had the important advantage of having continuously before them the whole subject of physics rather than its component parts.

For objective judgment of results we have only one criterion. Toward the end of the year the students following this course of study were given two objective achievement tests, one our own, one constructed by an external examining body. Another group in the school, completing a course extending over a year and a half but covering essentially the same ground, took the same two tests. The group which followed the new program did markedly better than ever before, in comparison with the other group following the longer course.

GLASS FOR MEDICAL DEFENSE WORK

American chemists and glass makers have overcome the threatened war shortage of an important German-made medical glass by learning how to make this rare glass here, W. L. Munro, president of the American Window Glass Company announces.

The particular glass in question is the very thin and clear glass used as cover slips. Like the cloth slip covers used by careful housewives to protect furniture, these glass cover slips are used to protect blood or other material being examined under a microscope.

Medical examinations of the men drafted for Army training will increase the need for this glass more than 33%, it is stated. During the World War, medical scientists were hampered in some of their work because this type of glass could not be made anywhere but in Germany and of course that supply was cut off.

The glass, is to be known commercially as Lustra Cover Glass, is extremely thin and practically colorless. Its thickness varies from 5/1000 of an inch to 10/1000 of an inch as compared with the normal home window glass that is 91/1000 of an inch in thickness.

A total of 36,000 separate ¾-inch square cover slips will only equal the amount of glass in a glass block 12 inches long by 12 inches with by 1 inch thick.

THE MATHEMATICS OF THE MODERN CURRICULUM

Carl G. F. Franzen
Indiana University, Bloomington, Indiana

When we attempt to give consideration to the problem of mathematics we find that we encounter various meanings of the term. Mathematics deals with aspects of measurement which are both quantitative and spatial. It is a type of activity which is ever present and never absent; it is a continuous process which attends us from the moment of conception to the door of death.

In the history of civilization mathematics has developed very slowly, due possibly to the fact that the genius of the race could not compass its abstruse abstractions until society had become a very complex affair. Since, in part, the development of the individual parallels that of the group of which he is a member, should there not then be a parallel development in his ability to understand and perform the abstactions that constitute the present stage of that society? In other words, if it has taken the race such a long time to acquire the concepts of fractions, decimals, and algebraic formulae, should there not be attention paid to a corresponding development in ability to use mathematical concepts by the individual?

There are certain skills which we need as we develop our individual progress in our own particular form of civilized society, but certainly we do not need to know or acquire all these skills at one time. It is obvious that the first thing we must do is to acquaint ourselves with spatial relationships. In other words, we must find out for ourselves the physical relationship which we bear to the rest of the world and the shapes and distances of the objects of our environment. In the next step we come into contact with concrete number relationships, many of them discrete in character. We are able to count and identify number properties of objects around us. The next step finds us combining space and number in their simpler forms of physical property, that is, size and shape, and time and distance. Up to this point mathematics for a consumer has been a continuous interlocking affair. It hasn't been a matter of geometry on Monday and Wednesday, arithmetic on Tuesday and Thursday, and advanced mathematics on the other days of the week.

But, as civilized society found a need more and more for the

invention and application of mathematics over and above that used by the ordinary individual, there arose the specialist, for whom mathematics became a compartmentalized affair. This stage, we must remember, was an orderly one in the development of a field of knowledge which had grown sufficiently to be recognized as having enough material to beget its own field of knowledge. It has always been to the interest of the specialist that further compartmentalization be extended and even perpetuated in our schools, because it spreads his particular field of knowledge among an ever-widening clientele, as well as serving to expand his ego. In order to advance his cause even further the specialist has invoked the malign influence of the doctrine of mental discipline to abet his cause and thereby set the stage for requiring all boys and girls to follow in his steps.

There is, however, a rising discontent with these stage properties of mathematics. Among many reasons for this discontent probably the outstanding one is a growing social realization that the need for any kind of mathematics is predicated on the interests of the group as well as on those of the individual. The group comes first with respect to what we call consumer education, a preparation for the duties of citizenship which lasts at least through the period of compulsory education. The bases for determining the content of consumer education are:

1. Frequency—the number of occasions in which the information functions;
2. Cruciality—the vital importance which the information has in the lives of individuals;
3. Generality—the number of individuals whom the information affects; and
4. Difficulty—the ability of the group to comprehend and use the information.

When the period of consumer education is past, the necessity for studying mathematics becomes an affair of the increased needs of the various social levels as well as an affair of the individual needs that lead on into specialization.

For almost two centuries mathematics has been in an entrenched position in both the elementary and secondary schools of our country, and only lately has it had to justify itself in the eyes of those taking it or proposing to take it. But today these entrenchments are being attacked and overcome on the secondary level through a reduction in the amount required and

the introduction of them as electives, and in the fact that there are several institutions which do not now require them for college entrance.[1] The latest enrollment figures from the Office of Education[2] give further evidence in support of the present situation. Whereas in 1928, 27 per cent of the students were taking algebra, 8 per cent advanced algebra, and 18 per cent plane geometry, in 1934, the corresponding enrollments were 19 per cent, 6 per cent, and 13 per cent. Similar data for today would undoubtedly show a continuing decrease.

Naturally, there have been attempts to palliate the situation. In 1923 the National Committee on Mathematical Requirements gave attention to the junior high school level and the idea of general mathematics. Since 1926 The National Council of Teachers of Mathematics has issued yearbooks which have dealt with various phases of the mathematics situation. In 1930 The National Society for the Study of Education issued its yearbook on arithmetic. The Joint Commission of the Mathematical Association of America, Inc. and The National Council of Teachers of Mathematics issued, in 1938, the preliminary form of its study, "The Place of Mathematics in Secondary Education."[3]

The 1923 recommendations tried to observe the principle, "eat your cake and keep it." The first thing to do was to choke as much mathematics as possible down the minds of elementary and junior high school youngsters. The next thing to do was to emasculate the advanced mathematics of the senior high school so as to fit all rather than to preserve it for a place of its own. These recommendations were aided by the advocates of social utility mathematics in making the elementary school a foul Gehenna for its inmates. Probably no subject has made the elementary school as unbearable an experience as has arithmetic, and, on the other hand, there is probably no subject whose content has been so dominated by adult opinion. In their zeal to cram all the mathematics possible within the compulsory age limit these adult social utility advocates have done violence to every known principle of selection, allocation, and placement of subject matter. Pupil activities and experiences have had little, if any, place in the processes of selection. For example, the

[1] Douglass, Harl R., "Let's Face the Facts," *Mathematics Teacher*, February, 1937, pp. 56–62.

[2] "Registrations in Mathematics," Text by Carl A. Jessen, *School Life*, March, 1937, p. 211.

[3] "The Place of Mathematics in Secondary Education," A Preliminary Report, Edwards Brothers, Inc., Ann Arbor, Michigan, 1938.

study of taxes, stocks and bonds, various forms of discount, and investments is a far-fetched affair for elementary and even junior high school pupils. This statement does not negate the value of such information. We need to learn something about the mathematics of these activities, probably toward the end of the senior high school period, but anyone who would teach it below the ninth grade surely has forgotten his own childhood. We have spent so much time in trying to teach comprehension of these matters that the mathematics involved has become a sideline to such an extent that youngsters come into the senior high school mathematics courses unable to perform the ordinary mathematical operations. Their minds have been so cluttered up with the agonies of trying to find some sense to the problem that the mathematics of the problem has been almost disregarded. Even the latest and most up to date report, that of 1938, has continued in the same grievous ways of error, where, on page 114, the topic, "Using Arithmetic in Problem Situations," includes such mathematical performances as discount, commission, banking, investment, taxation and insurance.

Now I believe that the study of mathematics is of value to all the members of our society, but, I wish to emphasize, in varying degrees. This belief has been intensified after reading Eric Temple Bell's *The Search for Truth* and Launcelot Hogben's *Mathematics for the Million.*

How, then, might it be possible to restore the study of mathematics to its rightful place in the schools?

1. In the elementary school incorporate the plan supported by L. P. Benezet[4] and ably seconded by Guy M. Wilson,[5] who says, "If you continue to teach arithmetic as now commonly taught, you might just as well throw it out entirely." Instead of the present type of formalized arithmetic in the first six grades we shall substitute an acquaintanceship and familiarity with mathematical experiences that are concomitant with the various grade-age levels of the youngsters. Formal work on the fundamentals will begin with the sixth grade. Fractions and decimals enter the picture in the seventh or even as late as the eighth grade. But, most important of all, the problems to be solved are not book problems, but those that deal with the everyday experiences of the pupils.

[4] Benezet, L. P., "The Story of an Experiment," *Journal of the National Education Association*, November, 1935; December, 1935; and January, 1936.

[5] Wilson, Guy M., "Useful Drill," *Journal of the National Education Association*, March, 1936, p. 84.

If such a program is adopted, think of the hours that will be salvaged for more time to be spent on reading. Think, also, of the life of dread that will be removed from the arithmetic-haunted boys and girls, because their learning activities will be keeping pace with their powers of understanding.

2. In the junior high school area emphasize the drill and mastery of fundamental operations and introduce problems of adolescent characteristics. The applications of arithmetic to other fields will be taught in those fields—not in the mathematics classes. For example, the mathematics of taxes will be taught in the social studies classes, and the mathematics of formulae will be handled in science or shop. Such other mathematics as may be introduced will be for the purposes of mathematical need and use on this level comparable to those of the fundamental operations, that is, if any algebra, geometry and trigonometry enter in they will be there because they are to be considered fundamental operations on the junior high school level.

3. For most pupils formal mathematics will end with the junior high school period. For those who want and enjoy advanced mathematics there will be, beginning with the tenth year, the compartmentalized mathematics of a rigorous type, yet tempered by correlations of mathematical fields, as suggested on page 129 of the 1938 report. Some mathematics will even have to be postponed and taught as a part of adult education, where and when the felt need for it has arisen.

Enrollments in advanced mathematics classes will be smaller, but a much more worthwhile job can be done. Those who acquire their fundamental operations by the end of the junior high school period and then apply them in all their other courses will see a real meaning to the place of mathematics in life, while those who go on with the advanced and elective courses will find something to challenge the best that is in them and to encourage them further to discover, with the aid of the teacher, the significance of mathematics as a mode of living in a complex society.

HIGH SPEED PHOTOGRAPHY

Indoor photographs at a speed of 1/30,000th of a second are possible with a new lighting unit commercially available. This speed will stop practically any moving object except a rifle bullet, so motion of the subject is completely eliminated as a problem to the photographer. Entirely natural and unposed expressions can be recorded, even with a nervous child, or an active animal.

EASY ATOMIC DRAWINGS

Philip B. Sharpe
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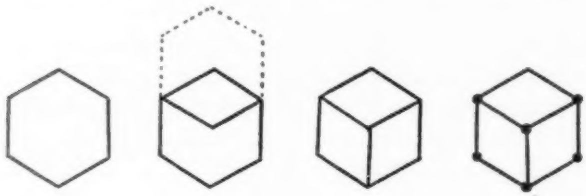
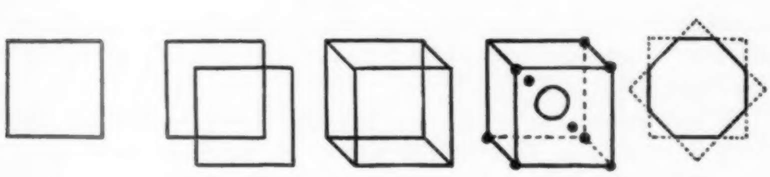
Conventional chemistry stencils make no provision for the rapid and easy drawing of fairly good and uniform models of atoms such as are used to illustrate atomic and electron theory. My pupils, at least, have many opportunities to draw atoms for tests and homework, and the problem of supplying them all with compasses or other devices which may be use for the purpose has been solved in several ways, some of which may prove useful to other teachers.

There seem to be two common ways of representing atoms on paper. The device of concentric circles which is perhaps the most popular one is easily implemented by laying coins of various size



1. 2. 3. 4.



5. 6. 7. 8. 9.

on the paper and tracing around them. I imagine that this trick is familiar to almost everyone.

But a collection of brass, iron, or fiber washers is better. They exist in a wide range of sizes: each washer gives two circles instead of only one: they are cheaper and less liable to move than the coins.

A still better trick, I think, is the drawing of octagons. They point the placing and number of electrons in accordance with the Octet Theory, although they do it in a two dimensional figure. They can be made by tracing once around an eight sided nut or twice around a four sided nut as indicated in figure 9. Eight sided

nuts are hard to obtain, although washers, four sided nuts, and six sided nuts are stocked in many sizes by almost all hardware stores. Nuts $\frac{5}{8}''$ to $\frac{3}{4}''$ outside diameter are convenient in size. The hole in the nut can be used to trace the nucleus or hydrogen atoms or helium atoms, or all three.

The other common way of representing atoms, as cubes, is the one I prefer as it portrays the Octet Theory in three dimensions. To draw uniform cubes on anything but cross-section paper is a laborious and time-consuming task. But finally it occurred to me that a common hexagonal nut is just the thing needed. It is laid on the paper and traced around, giving figure 1. Then it is moved slightly and two sides are traced around, giving figure 2. One more line is needed, which can be made with any side of the nut, or with a free-hand stroke of the pencil, and the drawing is completed, figure 3.

It takes far less time to do than to describe. Then the electrons can be sketched in free-hand, as shown in figure 4. The one corner which does not show is always assumed to have or lack its electron like the one opposite to it on an imaginary line drawn through the center of the cube, and the electrons are sketched on with this convention in mind. (The one that is hidden is like the one that hides it.)

It is not possible to show concentric cubes and so show inner shells by this method, but I do not find it necessary to do so in actual experience. However, if anyone thinks it is desirable to do so, here is another trick. Use a square nut instead, producing first figure 5, then 6, then 7.

As a refinement on this trick, it is well to make three of the lines dotted as in Figure 8. It keeps the students from going crazy (like Paul Bunyan's loggers) from trying to figure out which is the near and which is the far side of the cube.

BLOOD PRESSURE LINKED WITH BODY BUILD

Broad-chested persons have a hereditary predisposition to high blood pressure and narrow-chested persons are born with a predisposition to low blood pressure, according to figures collected by Dr. S. C. Robinson and Marshall Brucer and reported in summary by the Journal of the American Medical Association.

"The difference in susceptibility of hypertension (high blood pressure) in persons of contrasting body build extremes was unusual," comments the editor of the A.M.A. Journal.

Only 4% of the narrow-chested men had systolic pressures over 140 mm., whereas 22% of the broad-chested men belonged definitely in the high blood pressure class.

A SIMPLE HIGH DISPERSION SPECTROMETER

ROY D. BLACK
Wabash High School, Wabash, Indiana

The new Wood Replica Diffraction Gratings* which are mounted in Bakelite rings which may be held in the standard optical lens supports, make possible the construction of efficient, simple spectroscopes or spectrometers. This type of instrument is adaptable to both physics and chemistry classes. It is suitable for the detection of metals in Bunsen flames and teaches in a simple and effective way the principles of the larger instruments. It may be constructed in less than an hour by any teacher or pupil.

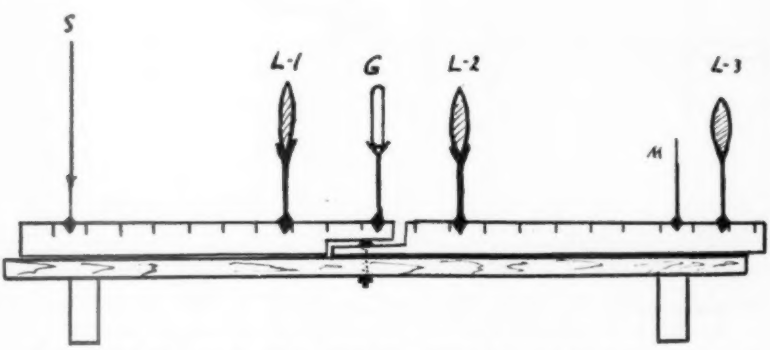


FIG. 1. Arrangement of gratings and simple lenses to form a spectroscope. L-1 collimating lens, L-2 and L-3 telescope lenses, G grating, S cardboard slit, M marker or recticle.

The materials needed are a wooden base similar to the usual force board used in the study of the composition of forces, a meter stick cut in half and the usual lens and screen holders of the elementary optical bench and three lenses such as are found in the usual physics laboratory. Achromatic lenses are not at all necessary. When simple double convex lenses are used it is only necessary to change the focus of the eyepiece slightly when viewing various parts of the spectrum. The diagram illustrates its construction.

The collimator lens, L-1, should have a focal length of about 20 to 30 centimeters and is placed slightly less than its focal

* The Wood diffraction grating replicas may be purchased from W. M. Welch Mfg. Co., Chicago, Illinois.

length away from the cardboard slit which is held in the regular screen holder. The diffraction grating replica which may be one of the $2.00 elementary type, is placed in a standard lens support as shown. If one of the 1 inch aperture circular replicas grade A or B is used the resolution is then improved and compares favorably with that of prism instruments selling for around $100. If a more expensive replica is used, longer focus and better lenses should be employed to secure the full resolution of the grating. A standard microscope eyepiece instead of a simple lens can also be used to advantage. Either the 4813 or

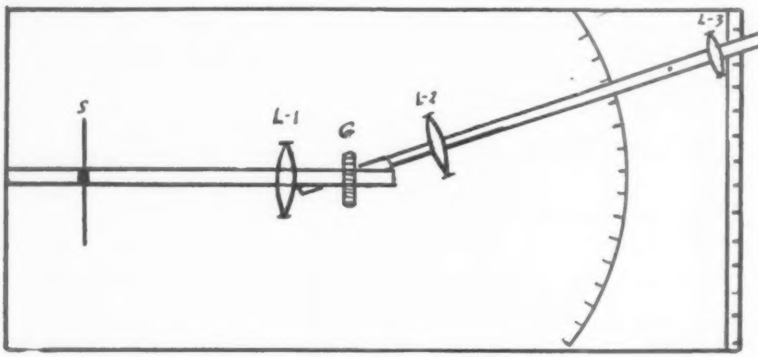


FIG. 2. Plan showing graduated circle and linear scale.

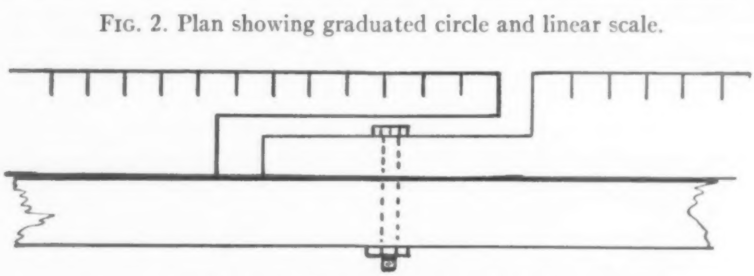


FIG. 3. Details of notched meter stick. Held to base board with loose fitting 832 machine bolt.

14,438 line replicas can be used. The coarse ruling gives a more brilliant spectrum but it is shorter. This shortness of the spectrum can be compensated for by using a 5× or 10× eyepiece.

The telescope lens L-2 should have approximately the same focal length as the collimating lens and its distance from the grating replica is not important. The eyepiece lens L-3 may be a simple lens and its focal length should be about five centimeters or less for best results. The pointer is the ordinary marker which slips on the standard meter stick. It is placed approximately at

the principal focus of the eyepiece. The meter stick must be notched as shown, since it must rotate about a point directly underneath the replica grating. Details of this notch are shown in figure 3. This section of the meter stick swings about a bolt as a pivot.

A simple protactor can be placed under the meter stick or a circle may be laid out and marked in degrees as indicated in figure 2. The cardboard shield is optional but its use will prevent stray light from entering the grating. The slit, *S*, is made by cutting a slit 30 mm. × 1 mm. in a piece of cardboard about 15 cm. square. The lighting in the room in which the instrument is used should be as subdued as possible.

Light sources which may be examined are neon, argon, and mercury vapor lamps, and of course such materials as may be vaporized in flames, such as Li, Ca, Sr, Ba, Th, B, Na, etc. Absorption spectra of solutions may also be seen by placing a test tube containing the colored solution in front of the slit and passing the light from a 60 watt lamp through the solution and into the slit.

It is a simple matter to calibrate the instrument to read wave lengths and this is an interesting exercise for the physics student. The method is to find certain known wave lengths and indicate these on the graduated circle or use a circle marked in degrees and plot a calibration graph; plotting wave lengths against degrees. A linear metric scale may be put on as shown if desired. Standard wave lengths are as follows:

Metal	*Color*	*Wave Length-Millimicrons*
Lithium	Red	670
Sodium	Yellow	589
Potassium	Red	768
	Violet	404
Strontium	Sharp blue line	460
Thallium	Green	534

If the lenses are fair quality, and focal length is about as indicated, the instrument will show a distinct double line for Na. even in the first order. By swinging the telescope arm through a larger arc the longer and less brilliant spectra of the second order may be observed. If a Wood replica grating is used it will be found that the first order spectrum on one side is much more brilliant than on the other and this spectrum should be used.

For vaporizing substances in the flame asbestos paper may

be soaked in a solution of the salt and wrapped around the Bunsen burner. Another method is to use a pyrex test tube filled with cold water and the test tube dipped into a solution of the salt and the bottom of the test tube then held in the Bunsen flame. The salt solution which adheres to the outside of the test tube colors the flame and the cold water prevents the glass from getting hot enough to color the flame. This method will be found more satisfactory than the usual platinum wire, as it may be more quickly and readily cleaned.

If sunlight is directed onto the slit a great number of Fraunhofer lines of the solar spectrum can be seen. If the slit is made sufficiently narrow the "D" line will be seen as a distinct doublet.

If it is impractical to darken the room a hood can be made by bending a sheet of black cardboard over the instrument so as to form an arch and holding it to the base with thumb tacks.

After the meter sticks are notched and the holes drilled in the center of the base board for the bolt about which the telescope arm swings it is possible to assemble the instrument in 5 or 10 minutes.

It is thus possible to provide duplicate sets so that the entire class may work on the experiment at one time.

VENUS MAY BE NEXT PLANET SUPPORTING LIFE

Venus may be the next planet to support life, when this troubled earth is dying of old age. And the red planet Mars may already have had its fling as a world inhabited by life of high order.

These striking possibilities are deduced from latest physical evidence reported by Dr. H. Spencer Jones, Astronomer Royal of Great Britain in the annual report of the Smithsonian Institution, just issued.

Spectroscopic studies in the past few years have revealed no trace of water vapor in the rather heavy atmosphere of Venus; strange, considering the clouds over the planet. Also, there is no discernible free oxygen in the atmosphere of Venus, but much more carbon dioxide than in the air of the earth. From these clues, Dr. Jones pictures Venus as a world somewhat like the earth millions of years ago, when life started.

"Any life on Venus can be, at the most primitive plant life," he concludes.

Regarding life on Mars, Dr. Jones declares:

"At present, there can be no life of a very high order unless organisms have been able to make adjustments to conditions of atmosphere and temperature which cannot be imagined on earth."

"In Mars", he adds, "we see a world where conditions probably resemble those that will probably prevail on earth many millions of years hence, when most of our present atmosphere will have been lost. Mars appears to be a planet of spent, or nearly spent life."

A NOTE ON SIMPLE INTEREST

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University of Wichita, Wichita, Kansas

Most texts on Mathematics of Finance define simple interest as "interest which is proportional to the time" or "interest which is calculated on the original principal during the whole period of the transaction." Compound interest is generally defined as the difference between compound amount and original principal, where compound amount is defined as "the total amount accumulated at the end of some given time during which interest is added to principal at certain regular periods, and the interest for each succeeding period is calculated on the basis of the new principal thus obtained." The fundamental assumption is also made in the texts that all money is productive, even money received as interest, and must therefore yield a return. The beginning student in Mathematics of Finance is apt to become confused, however, with regard to certain types of transactions in which the calculations may be made by use of simple interest formulas only, and yet the effect of the transaction on both parties involved is that of compound interest.

Suppose A borrows P units of money from B. For the purpose of illustration, let us assume that money can be invested at a rate of i per period but at no other rate. The contract for repayment might be one of the following plans:

I. At the end of n periods of time A repays $P+Pni$ to B.
II. At the end of n periods of time A repays $P(1+i)^n$ to B.
III. At the end of each of n periods of time A pays Pi to B and at the end of the nth period repays the P as well.
IV. An equal payment of R is made by A to B at the end of each period for n periods. Each payment of R includes both interest on the unpaid principal and a portion of that principal so that at the end of n periods the entire original principal has been repaid with interest.

Let us assume that the number of periods is integral and greater than one and propose in connection with each of plans I, II, III and IV, this question: Does B receive simple or compound interest for the use of his money? (Or, what is equivalent, does A pay simple or compound interest for the use of B's money?)

It is clear even to the beginning student, that B receives simple interest in plan I and in plan II he receives compound interest on his money. But the beginning student is apt to judge that in plan III simple interest is received, for the interest paid is computed on the original principal throughout the entire period of the transaction; that is, *the method of computing is that of simple interest*. However, according to our fundamental assumption the interest payments of Pi are productive, and the question of whether they are actually invested or not does not affect the theoretical aspects of the problem. Indeed, these payments form an annuity, the lump sum value of which on the date of repayment of the original principal is certainly not Pni, but is equal to

$$Pi\,\frac{(1+i)^n-1}{i}=P(1+i)^n-P$$

which, by definition, is compound interest on P. From the point of view of both A and B compound interest is involved in plan III, even though the person who does the calculating computes the interest on a constant principal using simple interest formulas.

If it is considered possible to invest the interest payments at a rate r different from i, the computation is complicated somewhat but the theoretical aspects of the problem are the same, as long as we consider the interest payments to be productive.

In plan IV the construction of an amortization table showing the gradual extinction of the debt is easily effected by means of simple interest computations, once the periodic payment has been determined. However, in order to determine this periodic payment the student considers the original principal P as the present value of an annuity whose periodic rent is R and obtains R from an annuity table. Since the annuity table is constructed according to the concept of compound interest, confusion is apt to arise as to whether the transaction has the effect of simple or compound interest on the parties involved.

In order to make it easier for the beginner to judge whether in any transaction, the effect on the parties concerned is that of simple or compound interest, the following explanation might well be attached to a discussion of simple and compound interest.

The effect of simple interest is obtained in a transaction lasting more than one period of time if the interest is computed on

the original principal alone, and *if the interest is paid off only at the time the original principal is repaid.* In case interest is paid off before the original principal is repaid, or if interest on any part of the principal is paid off before that part of the principal is repaid, the effect is that of compound interest.

ANNUAL MEETING OF THE AMERICAN SCIENCE TEACHERS ASSOCIATION ASSOCIATED WITH AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The annual meeting will be held in Philadelphia, Pa., December 30, 1940 during the convention of the American Association for the Advancement of Science, in the same city.

The program is planned to include:

Morning Meeting: President Harry A. Cunningham, presiding

Address
  New Types of Glass and New Techniques Exhibits.
  Dr. Albert E. Marshall, President, Rumford Chemical Company
  Presentation of the Oersted Medal to an Outstanding Teacher of Physics, by the American Association of Physics Teachers.
Television
  Demonstrations and Discussion.
  Mr. T. F. Joyce, Vice-President of R.C.A., and members of his staff.

Luncheon Meeting: Dr. Otis W. Caldwell, presiding

Address and Demonstrations.
  Taste and Smell.
  (Materials to illustrate will be passed out between courses)
  Dr. Albert F. Blakeslee, President of the American Association for the Advancement of Science, and Director of the Dept. of Genetics of the Carnegie Institute of Washington, Cold Spring Harbor, N. Y.

Afternoon Meeting: Vice-President Ralph K. Watkins, presiding

Symposium
  The Place of Science in General Education
  This will include such questions as:
    Should there be changes in content and approach?
    What efforts can be made to interest more students in science courses?
    Has national preparedness placed added responsibilities on science teachers?
Speakers include:
  Dr. Watson Davis, Director of Science Service
  Dr. Oscar Riddle, Investigator, Carnegie Institute of Washington, Cold Spring Harbor, N. Y.
  Dr. K. Lark-Horovitz, Dept. of Physics, Purdue University

All persons who are interested are invited to attend. If you would like to have one of the final printed programs mailed to you, please address the Secretary,

DEBORAH M. RUSSELL
State Teachers College
Framingham, Mass.

INCONSISTENCIES IN NUMBER CLASSIFICATION

CECIL B. READ
University of Wichita, Wichita, Kansas

A student in the writer's class raised the question: "If the discriminant b^2-4ac of a quadratic equation is negative, are the roots irrational?" According to one rather widely used text the roots are irrational for the statement is, "If a, b, and c are rational and b^2-4ac is not a perfect square, the roots of the equation are irrational." Another text qualifies the statement just made with the additional phrase, "If the roots are real." Analysis of 32 books dealing with the topic shows a division of about two to one, the majority either stating or implying that the words "rational" and "irrational" apply only to real numbers. However there is a substantial minority which classify, either directly or by implication, a solution such as $3+\sqrt{-7}$ as irrational.

Apparently the difficulty comes in the classification or definition of the terms rational and irrational numbers. With a very few exceptions, a rational number is defined as one which can be expressed as the quotient of two integers. The rare exceptions are usually definitions which can readily be shown to be equivalent to this. A considerable number of texts think it necessary to add a statement such as, "zero, also, is a rational number." Others specifically exclude from the class of numbers which can be expressed as the quotient of two integers, any number which would involve division by zero. For the moment we will merely point out the fact that zero is or is not considered an integer, depending upon the text book in use.

The definition of irrational number is by no means agreed upon; among others, the following definitions are encountered:

a. Any number which cannot be expressed as a quotient of two integers
b. Any real number which cannot be expressed as the quotient of two integers
c. Any real number not rational
d. A ratio which is incommensurable with one
e. A number which can not be expressed exactly as the quotient of two integers
f. Any number not rational but which may be represented approximately by means of rational numbers

g. Definitions based on a sequence or upon a Dedekind cut.

A mere glance at the list makes it obvious that depending upon the definitions used, complex numbers may or may not be classified as irrational.

It was pointed out previously that there is no uniformity regarding the classification of zero as an integer. Without detailed analysis of the number of books giving each definition, it may be stated that many texts are not clear as to whether zero should be included in the group of integers. For example one text uses a definition which specifically includes zero and another specifically excludes zero, others are indefinite.

As an example of another inconsistency, some books specify that $a+bi$ is a pure imaginary when $a=0$ and $b=0$. Others specifically point out that zero is a pure imaginary, at least one author calls attention to the fact that zero is the only number which is common to the real system and the system of pure imaginaries.

Granted that some of these distinctions are technical and perhaps trivial, they still bring out the fact that even in mathematics which is supposed to be the exact science, we are not in agreement as to the definition of the terms employed. It would seem that we could agree on definitions for the elements of our number system, at least on definitions that are to be used in beginning texts. The facts are that writers of elementary texts fail to agree on the system of classification of numbers, neither do they call attention to this disagreement.

CHEMISTRY AND THE FARM FOLK SCHOOL

RALPH E. DUNBAR
North Dakota Agricultural College, Fargo, North Dakota

The recently organized farm folk school at the North Dakota Agricultural College offers a unique educational opportunity for young men. The school offers not only courses in technical agriculture but also courses which deal with the social, cultural, and economic relationships of rural life. North Dakota is essentially an agricultural state. Such manufacturing industries as are found in the state are primarily concerned with processing agricultural products. The farm folk school is dedicated to helping young men solve the problems of production and distribution, and to

the problem of living a wholesome life on the land. The only entrance requirement is an interest in agriculture. The farm folk school is a short course. Its enrollees vary in age, educational training, background and experience. The courses are taught on an adult level.

The farm folk school course of study covers two winter periods of fifteen weeks each, divided equally into three terms of five weeks. A total of fifty-one subjects are offered of which thirty-six must be completed for final certification. Students select six subjects per term. The present program includes eight distinct courses in Agricultural Economics, eight in Agricultural Engineering, two in Agricultural Entomology, five in Agronomy, seven in Animal Husbandry, one in Animal Pathology, one in Bacteriology, two in Dairy Husbandry, one in English, three in History and Sociology, four in Home Economics, three in Horticulture and Forestry, one in Plant Pathology, three in Poultry Husbandry, one in Physical Education, and one in Chemistry. An additional total of six group participation courses are offered in the evenings and include Club Organization and Parliamentary Practice, Public Speaking, Personal and Social Development and Family Relations, Community Music, Plays and Programs, and Public Discussions.

The course in chemistry, specifically referred to as "Farm Chemistry," includes a brief study of the chemistry of those elements which affect our daily life. How to read and understand the labels on a sack of commercial livestock feed, a can of paint, a sack of commercial fertilizer, chemical tests on the value of insecticides and fungicides, using farm raw materials in chemical processes, the chemist in control of purity of food and fabrics, paints and varnishes, and water are considered in turn. The students enrolled in this course in Farm Chemistry are predominately high-school graduates. They differ greatly, however, in the type and extent of their science training. Few, if any, of the group contemplate continuing their studies in college. The course is consequently taught as a service course with no thought of producing efficient chemists. The basic idea has been to make these young men, not active producers, but intelligent and appreciative consumers in a world of chemistry and science.

The class meets daily, five times a week, for six weeks. A total of twenty-six major topics, each directly correlated to the student's daily experience, are discussed. Periodic examinations are used to check the efficiency of lecture and reading assign-

ments. The following topics have been included in the course as offered during the past two years.

1. The Inevitable Presence and Influence of Chemistry.
2. The Foundations of Chemistry.
3. Chemistry in the Home.
4. Chemistry of the Automobile.
5. The Chemical Composition and Nature of Water.
6. The Chemical Analysis and Use of Water.
7. Care and Chemical Treatment of Water.
8. The Clothes We Wear.
9. Synthetic Fabrics.
10. Plant Growth and Food.
11. Insecticides and Fungicides.
12. The Chemical Nature of Foods.
13. Food Fads, Poisons and Adulterants.
14. Nutritional Requirements for Livestock.
15. By-products from Farm Animals.
16. Products from Wheat.
17. Products from Flax.
18. Products from Corn and Power Alcohol.
19. Miscellaneous Farm By-products.
20. Commercial Livestock Feeds.
21. The Chemical Nature of Commercial Fertilizers.
22. Results of Applied Fertilizers.
23. Paints for Protection and Permanence.
24. Varnishes for Variety.
25. Lacquers and Synthetic Finishes.
26. Paint Labels and Lies.

PLASTER OF PARIS MOLDS IN ELEMENTARY SCIENCE

Charles H. Stone
Orlando, Florida

1. *Preparation of a plain mold.* Procure at the ten-cent store an assortment of small jelly molds made of aluminum; these can be bought two for a nickel for the smaller ones and so on for the larger ones. Grease the inside of a small mold with a very thin layer of vaseline, not enough to be visible to the eye. Mix up in another dish some plaster of Paris to a thick cream, fluid enough, however, to pour well. Pour this into your greased mold and jar the dish on the desk to cause the thick substance to settle and drive out air bubbles. Let stand for some time; the time required will depend largely upon the quality of the plaster used and also upon the amount of water which must be evaporated before the process is complete and the plaster has "set" or become hard. Do not be in too much of a hurry to remove the

cast from the mold; haste in this respect often results in a broken or imperfect product. One may make paper weights this way for office use.

2. *Colored products.* To the water to be used in mixing your plaster add a little of some strong solid dye; a very small amount will answer. Then proceed as in 1. Very pleasing products can be made this way.

3. *Marbled effect.* Mix up your plaster with water as usual. Then, just before pouring, add a few specks of two or three different solid dye stuffs and stir well; pour at once. None of these added dyes will dissolve enough to color the whole mass so that you may get a marbled effect.

4. *Two color effect.* Procure if possible a jelly mold with a design stamped in the bottom; the one we have used represents a flying bird. Grease the design. Prepare a small amount of your plaster, using color as desired, and carefully pour into the mold so as to fill the design only. With a slender glass rod you may move the mass here and there to fill out the outline of the figure. Let stand till thoroughly set. The design may now be carefully removed from the mold, its edges trimmed where necessary to give the perfect shape of the figure and then returned to the mold. Now prepare another mess of plaster, using a contrasting color or just plain white as desired and pour upon the already hardened design. Let stand till thoroughly set. Then carefully remove by inverting the dish and jarring it gently. The design should fall out showing the bird (or other figure) standing out in relief against a contrasting background of another color.

5. *Frosted chocolate cake with lemon filling.* Using an ordinary round berry dish (about four inches in diameter sold at ten-cent store) make a thin layer of plaster colored with some brown dye. Let set. When thoroughly hard pour upon this layer a thin layer of plaster colored lemon yellow with some suitable dye and let set. Then pour upon this another chocolate-colored layer and let set. Finally pour on top as a final layer some of the pure white plaster and let set. When the whole is thoroughly hard, remove from the dish and with a fine saw cut into as many pieces as desired. "Refreshments" may now be served.

6. *Mounted picture.* From the pages of some magazine cut out a small picture, preferably colored. Trim this to fit the size of dish in which the cast is to be made. Wet the picture well with water and place it, face down, in the bottom of the dish, center-

ing it properly, and pressing tight against the dish bottom. Prepare your plaster and pour onto the picture. Before the mass has set insert in the soft plaster, loops of wire so that when the plaster has set the loops may be used to hang the mount on the wall. Remove the cast after it has become quite hard. With a knive remove any of the plaster which may have crept under the edges of the picture.

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PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1660. *T. C. Pan, National Chekiang University, China, Roy Wild, New Boston, Mo., C. W. Trigg, Los Angeles*

1661. *Roy Wild, New Boston, Mo.*

1670. *Proposed by Garrett Freeleigh, Watertown, N. Y.*

Show that the area of a triangle, whose sides are a, b, c, is

$$\tfrac{1}{4}\sqrt{2a^2b^2+2a^2c^2+2b^2c^2-a^4-b^4-c^4}.$$

Solution by Alton Dimmick, Ithaca, N. Y.

From the relation $\text{sine}^2 C+\cos^2 C=1$ and the law of cosines,

$$\begin{aligned}\text{Area } \triangle ABC &= \tfrac{1}{2}ab \sin C\\ &= \tfrac{1}{2}ab\sqrt{1-\left(\frac{a^2+b^2-c^2}{2ab}\right)^2}\\ &= \tfrac{1}{4}\sqrt{2\Sigma a^2b^2-\Sigma a^4}.\end{aligned}$$

Solutions were also offered by Cecil B. Read, Wichita, Kan., Clara Broadhurst, Fayette, N. Y., M. Kirk, West Chester, Pa., Robert E. McKay, Middleport, Ohio, Clayton Williams, Clarkstown, N. Y., George J. Ross, Brooklyn, N. Y., Aaron Buchman, Buffalo, N. Y. and by Morgan Harris, Watertown, N. Y.

1671. *Proposed by Hugo Brandt.*

For the curve $y=x^x$, find

a. The value for $x=0$,
b. The minimum value for y,
c. The inclination of tangent for $x=1$.

Solution by George J. Ross, Brooklyn, N. Y.

(a)
$$y=x^x=e^{\log x^x}=e^{x\log x}=e^{\log x/(1/x)}.$$

$$\lim_{x\to 0}\frac{\log x}{\frac{1}{x}}=\lim_{x\to 0}\frac{\frac{d\log\phi}{dx}}{\frac{d\left(\frac{1}{x}\right)}{dx}}=\lim_{x\to 0}(-x)=0.$$

$$\therefore\quad \lim_{x\to 0} e^{\log x/(1/x)}=1.$$

(b)
$$\frac{dy}{dx}=x^x(\log x+1).$$

for minimum: $\quad x^x=0 \quad\text{or}\quad \log x+1=0.$

An examination of the second derivative gives

$$\log x=-1 \text{ a minimum.}$$

$$x=\frac{1}{e}.$$

$$\therefore\quad y=\left(\frac{1}{e}\right)^{1/e}.$$

(c) Substituting $x=1$ in $\frac{dy}{dx}$ gives 1

$\therefore$ Inclination is 45°.

Solutions were also offered by M. Kirk, West Chester, Pa., Arthur Danzl, Collegeville, Minn. and the proposer.

1672. *Proposed by Cecil B. Read, Wichita, Kan.*

If $\tan x=\tan^3 y$ and $\tan 2y=2\tan z$, prove that $x+y-z=n\pi$.

Solution by the Proposer

$$\tan(x+y)=\frac{\tan x+\tan y}{1-\tan x\tan y}=\frac{\tan^3 y+\tan y}{1-\tan^4 y}=\frac{\tan y(\tan^2 y+1)}{(1-\tan^2 y)(1+\tan^2 y)}$$

$$=\frac{\tan y}{1-\tan^2 y}=\tfrac{1}{2}\tan 2y=\tan z.\quad \text{Hence } x+y=n\pi+z.$$

Editors Note: Apologies are in order. In the statement of the problem as originally given the term "$\tan^3 y$" was the error replaced by the term "$\tan 3y$."

1673. *Proposed by William W. Johnson, Cleveland, Ohio.*

Solve for x:

$$\left(\frac{x-a+b}{x+a-b}\right)^2=\left(1+\frac{2x}{a}\right)^2+\left(1+\frac{2x}{b}\right)^2-9.$$

No solution was offered.

1674. *Proposed by Charles W. Trigg, Los Angeles.*

The area of a triangle is equal to the sum of the squares of its sides divided by four times the sum of the cotangents of its angles.

Solution by Aaron Buchman, Buffalo, N. Y.

If the altitude, h, be drawn to a side of triangle ABC, say side c, then, keeping in mind that the cotangent of an acute angle is positive, and of an obtuse angle, negative, it is easily shown that for all cases,

$$c=h(\cot A+\cot B).$$

Solving for h

$$h=\frac{c}{\cot A+\cot B}\cdot$$

Therefore the area of triangle ABC is

$$K=\frac{c^2}{2(\cot A+\cot B)}\cdot$$

In general

$$K=\frac{c^2}{2(\cot A+\cot B)}=\frac{b^2}{2(\cot C+\cot A)}=\frac{a^2}{2(\cot B+\cot C)}\cdot$$

Therefore

$$K=\frac{a^2+b^2+c^2}{4(\cot A+\cot B+\cot C)}\cdot$$

In a series of equal ratios, the sum of the antecedents is to the sum of the consequents as any antecedent is to its consequent.)

Solutions were also offered by George J. Ross, Brooklyn, N. Y., Kenneth P. Carlson, Funk, Neb., John Hoyt, Cornwall, N. Y., Roy Wild, New Boston,, Mo., M. Kirk, West Chester, Pa., Clara Broadhurst, Fayette, N. Y., Everett N. Crandall, Alfred, N. Y., Arthur Danzl, Collegeville, Minn., Walter R. Warne, Rochester, N. Y., B. Felix John, Pittsburgh, Pa. and also by the proposer.

1675. *Proposed by S. V. Soanes, Upper Canada College, Toronto.*

Solve the system

$$x+y+z+w=10 \tag{1}$$
$$x^2+y^2+z^2+w^2=30 \tag{2}$$
$$x^3+y^3+z^3+w^3=100 \tag{3}$$
$$xyzw=24 \tag{4}$$

Solution by E. B. Escott, Oak Park, Ill.

The set of equations is equivalent to the set of symmetric functions

$$\Sigma x=10$$
$$\Sigma xy=a$$
$$\Sigma xyz=b$$
$$xyzw=24$$

squaring (1) and subtracting (2) and dividing by 2,

(5) $$\Sigma xy=35$$

multiply (1) by (2)

$$\Sigma x^3+\Sigma x^2y=300$$
$$\Sigma x^2y=200$$
$$\Sigma x\cdot\Sigma xy=\Sigma x^2y+3\Sigma xyz=350$$
$$\therefore\quad \Sigma xyz=50$$

Then since the coefficients of the equation of the 4th degree, roots x, y, z, w are $-\Sigma x$, Σxy, $-\Sigma xyz$, $xyzw$ we have the equation

$$x^4-10x^3+35x^2-50x+24=0$$

whose roots are 1, 2, 3, 4.

The solution is $x=1$; $y=2$; $z=3$; $w=4$ with any permutation of these roots (24 permutations) as a solution.

Solutions were also offered by Kenneth P. Carlson, Funk, Neb. John Hoyt, Cornwall, N. Y., George J. Ross, Brooklyn, N. Y., B. Felix John, Pittsburgh, Pa., M. Kirk, West Chester, Pa., Walter R. Warne, Rochester, N. Y., and also by the proposer.

STUDENT HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted to this department. Teachers are urged to report to the Editor such solutions.

1665. *Morris Greenfield, Los Angeles, Calif.*

1666. *King Allen, Morris Greenfield, Jack Hiehle, Max Himel, James Ito, Donald Mackenzie, Jack Mott, Carlton Moultrop, Alton Parker, Albert Paul, Yuzuru Sato, all of Los Angeles City College.*

1668. *Morris Greenfield, Alfred Faries, Max Himel all of Los Angeles City College.*

Error: In submitting problem 1678, October issue, a + sign should join the two fractions rather than the − sign as given. EDITOR.

PROBLEMS FOR SOLUTION

1687. *Proposed by D. L. MacKay, New York*

Determine an angle such that the sum of its six trigonometric functions equals a given quantity k.

1688. *Proposed by C. W. Trigg, Los Angeles*

From a point C on the circles with diameter BA, a perpendicular CD is drawn to BA. Find angle B such that $BD=K.CA$ and show that such an angle exists for all positive values of K. For what values of K will sin B be rational?

1689. *Proposed by F. E. Nemmer, University of Iowa*

Solve for x: $$\sqrt[3]{6x+28}-\sqrt[3]{6x-28}=2.$$

1690. *Proposed by D. L. MacKay, New York.*

Without using approximation methods solve

$$x^4-x^2(2x-3)=2x+3.$$

1691. *Proposed by D. L. MacKay, New York*

Solve for x: $\tan(\cot x)=\cot(\tan x)$

Solve for x: $\quad$ $\operatorname{Tan}(\cot x)=\cot(\tan x)$.

1692. *Proposed by Walter R. Warne, Rochester, N. Y.*

If E is the mid point of AB of triangle ABC and if AL is perpendicular to BC cutting CE in F, show that

$$AF=\frac{ab\sin C}{a+b\cos C}\cdot$$

SCIENCE QUESTIONS

December, 1940

Conducted by Franklin T. Jones

IMPORTANT QUESTIONS

What do you want in this Department?
(Tell the Editor and he will do his best.)
Should questions be aimed—

For Class Use?	For the Pupils?
For the Teacher?	For the General Reader?

Send in your "Do you Know the Answer" Questions.

Questions for discussion, examination papers, disputed points may be submitted to this department. They will be published together with discussion.

Please let us know what you are working on. It will be helpful to pass the information along.

Send all communications to my home address—Franklin T. Jones, 10109 Wilbur Ave., S.E., Cleveland, Ohio.

SOME QUESTIONS ABOUT WAR CHEMISTRY

111. What chemical very important in the manufacture of explosives, formerly made abroad, is now made in America?
(Sc. News Letter, Nov. 2, 1940)
112. How can loss of iodine from iodized table salt be slowed up or prevented?
113. What harmless use has been found for tear gas (chloro-picrin)?
114. What medicine will postpone surgical shock in wounded soldiers?
115. What vitamin is the morale vitamin?

Readers are invited to propose questions, or lists of five questions, preferably with brief answers for publication under headings similar to the above.

Answers to Questions in the October Issue

101. The first of the long list of plastics now known was celluloid. Its discoverer was John Wesley Hyatt, inventor of the Hyatt antifriction roller bearing.

102. The lightest strong metal is Dowmetal.

103. Xanthates are dithiocarbonates and are the product of the reaction in monomolecular proportions of an alkali metal hydroxide, in practice either KOH or NaOH, carbon bisulfid and an alcohol, in practice almost invariably an aliphatic alcohol. The wet reaction product is yellow to orange in color (whence the name xanthate). When dried the material appears as yellow powder. Xanthates are readily and completely soluble in water and form insoluble xanthates with a wide range of soluble metallic salts of molybdenum, mercury, silver, lead, copper, zinc, iron, etc. Every sulfid mineral appears to possess what might be described as inherent flotation speed or rate of flotation, and the sulfids of the elements just enumerated float with increasing slowness, much as in the order given. The precise function of xanthates in flotation circuits is to enhance the apparently natural flotation of sulfid minerals containing the ore. A non-wettable xanthate film of no more than one molecule in thickness spreads over the surface of certain mineral particles which renders them readily flotable. Flotation is employed in the separation of sulfid ores. Today and for several years past well over 90% of the world's tonnage of copper, lead and zinc has involved the flotation process.

104. Magnetic mines are not attracted up from the bottom of the ocean as the ship passes over them to explode as a contact mine against the ship. The magnetic mine consists essentially of a heavy square anchor, a mooring cable on a reel, a buoyant spherical mine case containing 300 pounds of TNT, a copper wire reaching from a copper float near the surface to a relay firing arrangement in the mine. Contact by any iron ship with the copper wire would set up the current to operate the firing apparatus. This mine was invented by an American—Ralph Cowan Browne, a self-educated electrical engineer from Salem, Mass.

105. Insects assist in carrying pollen from one flower to another and so help in plant reproduction.

EXPERIMENTS ARE POPULAR

903. *LIFE (Oct. 14, 1940, Pages 87–90) quotes experiments from Dr. Ira M. Freeman's "Invitation to Experiment."*

Experiments shown demonstrate—
- Travel of sound through strings;
- Focussing of sound waves by umbrellas;
- An old can shows relation of pressure to depth in liquids;
- Refraction of light with piece of glass and soda straw;
- The balancing paradox with forks, a needle and a cork;
- Surface tension with soap and pepper;
- Queer things about air currents;
- Try to make a candle burn in a tumbler of water;
- Get some marbles and explain some laws of collision.

What have you that is interesting in the way of experiments?

FLYING SPEED OF A BEE

905. How can you find out how fast a bee flies?
What do you mean by "lining" a bee?

IS KETTERING RIGHT?

905. *The opening paragraph by Charles F. Kettering in "Previews of Progress in the Coming Century" is:—*

"The ultimate aim of all industry, science, government and sociology is for a better life—better living conditions; better health; better food; better government; better houses; in fact, for better everything. And these can come about only in proportion as our daily routine and activities conform more nearly to nature's laws, which we understand so poorly at the present time."

The question is:

Are we measuring up to our opportunities in teaching Nature's Laws? What do you think about it?

Did you get your copy of "Previews of Progress" by writing to Henry G. Weaver, Director, Customer Research Staff, General Motors, Detroit, Mich.?

GENERAL INFORMATION TEST

902. *Test given by Charles R. Foster (GQRA No. 352), to boys of University School, Cleveland.*

(a) James Watt made the first practical application of steam to industry.
(b) Germany is experimenting on making "butter-coal."
(c) Elias Howe invented the sewing-machine. Goodyear invented vulcanization of rubber.
(d) Madame Curie specialized on radium.
(e) Dr. Harvey Cushing belonged to the medical profession.
(f) Insulin is used in the treatment of diabetes.
(g) Bronze is made from copper and tin.
(h) Differences between physics and chemistry—Physics, movements, etc. of matter: Chemistry, composition of matter.
(i) A planetarium is a building used for study of the heavenly bodies.
(j) Inventions associated with the names of—1. Cyrus McCormick, reaper; 2. Eli Whitney, cotton gin; 3. Marconi, wireless; 4. Morse, telegraph.

ARE WE MISSING THE BOAT?

906. *Some questions about Science and Mathematics.*
Your comments and added questions are desired.

We are living in a battling world and our very existence as a Nation is likely to depend shortly upon our ability to hit when we shoot if we can see the target (optics), and, if we can't see it, figure out where to aim so that our projectile shall reach the unseen target (ballistics, air pressures, speeds, deviations, gravity, etc.).

We must work metals (metallurgy), make explosives and fuels (chemistry), build ships and submarines (ship-building industry), design, manufacture, and fly aircraft of all kinds (air-craft industry), and so on. All of these activities call for trained man-power.

Are we training our pupils in such fundamentals as will help them carry on the work of this troubled world?

If so, why are we curtailing the study of mathematics and science?

Are not the fundamentals of knowledge vital to our National existence now centered around physics, chemistry, biology, meteorology, algebra, geometry and trigonometry?

Right now that we need this knowledge most, are we not diverting our attention away from the sciences and mathematics instead of intensifying their study?

What are we as teachers and school planners going to do about it?

SHALL WE MISS THE BOAT?

GQRA—DECEMBER, 1940—NEW MEMBER

353. Robert White, Champion Junior High School, Painesville, Ohio.

JOIN THE GQRA (Guild of Question Raisers and Answerers). More than 350 are already members. Teachers, pupils, classes, and individuals may become members by submitting questions or answers.

GQRA CONTRIBUTORS—YEAR BY YEAR

1933—October to December, Nos. 1 to 10;
1934—January to December, Nos. 11–47;
1935—January to December, Nos. 48 to 113;
1936—January to December, Nos. 114 to 154;
1937—January to December, Nos. 155 to 201;
1938—January to December Nos. 201 to 254;
1939—January to December, Nos. 255 to 313;
1940—January to December, Nos. 314 to 353.

BOOKS AND PAMPHLETS RECEIVED

HANDBOOK OF CHEMISTRY AND PHYSICS. Twenty-fourth Edition. Editor, in Chief, Charles D. Hodgman, *Associate Professor of Physics at Case School of Applied Science;* Associate Editor, Harry N. Holmes, *Professor of Chemistry at Oberlin College.* Cloth. Pages xviii+2564. 11.5×18 cm. 1940. The Chemical Rubber Company, 1900 W. 112th Street, Cleveland, Ohio. Price $3.50.

THINGS A BOY CAN DO WITH ELECTROCHEMISTRY, by Alfred Morgen. Cloth. Pages xiii+198. 13×19.5 cm. 1940. D. Appleton-Century Company, 35 W. 32nd Street, New York, N. Y. Price $2.00.

MATHEMATICS FOR EVERYDAY AFFAIRS, by Virgil S. Mallory, *Professor of Mathematics and Instructor in the College High School, State Teachers College, Montclair, New Jersey.* Cloth. Pages vii+471. 13×19 cm. 1940. Benj. H. Sanborn and Company, 221 E. 20th Street, Chicago, Ill. Price $1.28.

FOUNDATIONS OF MODERN PHYSICS, by Thomas B. Brown, *Professor of Physics, The George Washington University.* Cloth. Pages xii+333. 14.5×23 cm. 1940. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.25.

COLLEGE PHYSICS, by John A. Eldridge, *Professor of Physics, University of Iowa.* Second Edition. Cloth. Pages xii+702. 13.5×21.5 cm. 1940. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.75.

A DIAGNOSTIC STUDY OF STUDENTS' DIFFICULTIES IN GENERAL MATHEMATICS IN FIRST YEAR COLLEGE WORK, by Elizabeth N. Boyd. Teachers College, Columbia University Contributions to Education, No. 798. Cloth. 152 pages. 15×23 cm. 1940. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.85.

An Experiment in the Teaching of Genetics with Special Reference to the Objectives of General Education, by Austin Demell Bond. Teachers College, Columbia University Contributions to Education, No. 797. Cloth. Pages viii+99. 15×23 cm. 1940. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.85.

General Mathematics, Books 1, 2, and 3, by William David Reeve, *Professor of Mathematics, Teachers College, Columbia University*. Paper. 158 pages each. 19×27 cm. 1940. The Odyssey Press, Inc., 386 Fourth Avenue New York, N. Y. Price 64 cents each.

Learning the Ways of Democracy: A Case Book of Civic Education, prepared by The Educational Policies Commission, National Education Association of the United States and the American Association of School Administrators. Cloth. Pages vii+486. 14.5×23 cm. 1940. The Educational Policies Commission, 1201 Sixteenth Street, Northwest, Washington, D. C. Price $1.00.

Suggested Courses of Study and Teacher's Manual in Science for Vermont Secondary Schools, Grades 7–12. Issued by Authority of State Board of Education, Montpelier, Vermont. Paper. 128 pages. 15×23 cm. 1940.

Foods and Nutrition. A Guide for Use with the Instructional Sound Film "Foods and Nutrition," prepared by Melvin Brodshaug, *Erpi Classroom Films, Inc.*, and W. Hugh Stickler, *Advanced School of Education, Teachers College, Columbia University* in collaboration with A. J. Carlson and H. G. Swann, *The University of Chicago*. Paper. Pages iv+32. 13.5×20 cm. 1940. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price 15 cents.

Endocrine Glands. A Guide for Use with the Instructional Sound Film "Endocrine Glands," prepared by Melvin Brodshaug, *Erpi Classroom Films, Inc.*, and W. Hugh Stickler, *Advanced School of Education, Teachers College, Columbia University* in collaboration with A. J. Carlson and H. G. Swann, *The University of Chicago*. Paper. Pages iv+32. 13.5×20 cm. 1940. The University of Chicago Press. 5750 Ellis Avenue, Chicago, Ill. Price 15 cents.

Propaganda Analysis. An Annotated Bibliography by Edgar Dale and Norma Vernon. Series 1, Volume 1, Number 2, May 1940. Paper. Pages ii+29. 15×23 cm. Bureau of Educational Research, The Ohio State University, Columbus, Ohio.

Statistics of Public High Schools 1937–38. Bulletin 1940, No. 2, Chapter V. Statistical tables prepared under direction of David T. Blose, Associate Specialist in Educational Statistics. Text prepared by Carl A. Jessen, Senior Specialist in Secondary Education. Pages vi+92. 14×23.5 cm. Superintendent of Documents, Washington, D. C. Price 15 cents.

BOOK REVIEWS

Elements of Botany by Richard M. Holman, *Late Associate Professor of Botany in the College of Letters and Science of the University of California* and Wilfred W. Robbins, *Professor of Botany in the College of Agriculture of the University of California*. Cloth. Pages xi+392. 244 illustrations. John Wiley and Sons, Inc., New York. 1940. $2.75.

This is a college text designed for a one semester course. It is a companion to *A Textbook of General Botany for Colleges and Universities*, written

by the same authors. The latter book is for use in a full one year course.

This is the third edition of *Elements of Botany*. Since the last edition which came out about seven years ago researches in botany have been of such a nature that a new edition appeared to be justifiable. New aspects of the following items appear. Growth substances, hydroponics, root systems in relation to soil erosion, methods used in altering the duration of the life cycle of plants, artificial pollination, self sterility in commercial fruit varieties, efficiency of certain plants in the production of carbohydrates, economic importance of plant diseases, principles of control of the classes of weeds, economic value of certain plants and of various plant products, such as cellulose, alkaloids, glucosides, oils, latex, starch and proteins, "hardening of plants," short-day and long-day plants and methods employed to induce chromosome changes. This last item is of special significance.

A. G. Zander

Everyday Biology by Francis D. Curtis, Ph.D., *Head of the Department of Science, University High School, and Professor of the Teaching of Science, University of Michigan*. Otis W. Caldwell, Ph.D. Ll.D., *Professor Emeritus, Teachers College, Columbia University, and General Secretary of the American Society for the Advancement of Science*. Nina Henry Sherman, A.M., *Teacher of Biology, University High School, Ann Arbor, Mich*. Cloth. 17×23.5 cm. 503 illustrations, pages ii+698. Glossary, index. Ginn and Company, New York. 1940. $1.92.

This is the latest book on High School Biology by these prominent authors of this subject. It has been developed from an earlier book called *Biology of Today* which had quite a wide acceptance. It is quite a large book as these books go but the authors have marked those parts which to them based on research, seem to be most important. This allows for flexibility because schools do not all devote the same amount of time to their biology courses. The text material is divided into these 8 units: 1—Some Major Problems Which Living Things Must Solve. 2—Plants and The World's Supply of Food. 3—The Kinds of Living Things. 4—Conservation of Living Things. 5—Structures and Processes Concerned With Nutrition. 6—The Responses of Living Things. 7—The Control of Disease and the Improvement of Health. 8—The Continuance and Improvement of Living Things. Each unit closes with a short self-test on unit content, biologic terms, biologic principles. There are frequent exercises on scientific method and scientific attitude the results of which can be checked against a list of statements on these things at the end of the text. Good reference reading lists are appended to each unit.

A. G. Zander

The March of Medicine. Edited by the Committee on Lectures to the Laity of the New York Academy of Medicine. Cloth. 14×20 cm. No illustrations. Pages vii+168. Index. Columbia University Press. New York. 1940. $2.00.

This book contains a series of lectures (*6*) which had been given by the New York Academy for the general public. These lectures acquaint the public with the high lights of medical progress from the times of Elizabethan England down to the present day. It is a very interesting volume authoritatively written. It would seem that this book would be of value to those whose interest in medicine is of a marginal nature, such as instructors, physical educators, nurses, health instructors and teachers of biology. The latter group would, it seem, be especially interested because

these people must constantly answer questions on quackery, superstition and miraculous cures.

A. G. ZANDER

BIOLOGY IN THE MAKING by Emily Eveleth Snyder, *Science Department, Junior Senior High School, Little Falls, New York*. Cloth. 15×21 cm. 104 illustrations mostly pictures of prominent scientists in the biological field. Pages xii+539. McGraw-Hill Book Co., Inc. New York. 1940. $2.80.

This book presents short narrative accounts of the histories of the development of various biological principles. About one-third of the book is devoted to a discussion of classification, heredity and the cell theory. As the title suggests the content is largely historical. The narrative being built around the men who were and are the pioneer thinkers and workers in these various biological fields. The author begins with the great Greek physician Hippocrates and takes the reader to the decade just ended during which the first filtrable virus was isolated. Following each chapter is a short reading list. An interesting item in the book is a chronological list of the 125 scientists mentioned in the book, the years during which they lived, place of birth, and major contributions. A glossary and index are appended. This should be a valuable reference for biology teachers.

A. G. ZANDER

GENERAL PHYSICS FOR STUDENTS OF SCIENCE. by Robert Bruce Lindsay, *Hazard Professor of Physics in Brown University*. Cloth. Pages xiv+534. 14×23 cm. 1940. John Wiley & Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.75.

The outstanding characteristic of this book is indicated by the author's criticism of other general physics texts. He thinks them unsatisfactory largely because of "their avoidance of the mathematical methods natural and necessary for the development of the subject." With this point of view he assumes that physics students have a working knowledge of mathematics through calculus, and he makes complete use of the calculus in definitions and analysis. By this plan description and discussion can be greatly simplified and shortened. Subject matter requiring 700 to 800 pages in the non-mathematical type of book is here presented in 534 pages. Here than is a text admirably adapted to classes where two years of college mathematics are prerequisite to registration in physics. Such students will enjoy this book and make rapid progress; they come to physics eager to apply the principles of mathematics and are disappointed if the mathematical analysis is omitted. But for the many general physics students who have a very limited mathematical foundation the book will be of little value and will discourage them from further attempts to learn physics. In schools where it is not possible to group the students on the basis of preparation this book should be in the library for reference.

G. W. W.

A TEXT OF HEAT, by H. S. Allen, *Professor of Natural Philosophy in the University of St. Andrews*, and R. S. Maxwell. Part II. Cloth. Pages ix+318+xi. 13.5×22 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

This is the second volume of a two-book course in heat prepared for physics majors. Volume I, reviewed in March, 1940, is descriptive and based on experimental evidence, with a minimum of analysis. Part II is much more advanced, makes extensive use of mathematical analysis, and

emphasizes the theoretical aspects of heat. About half the book is devoted to a thorough treatment of the laws of thermodynamics. This starts with the descriptive and historical method used in Part I but soon changes to the analysis necessary for a satisfactory treatment of the second law, the properties of gases, and entropy. The mathematical theory of conduction is a continuation of the experimental treatment of this topic in Book I; this is also true of the short chapter on convection. Radiation is here treated in greater detail and includes the quantum theory of radiation. Statistical methods and probability are given special attention.

G. W. W.

BIOLOGY OF THE VERTEBRATES, by Herbert Eugene Walter, *Emeritus Professor of Biology, Brown University*. Revised Edition. Cloth. Pages xxv +882. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.00.

This biology text is remarkable for the many pertinent bits of related scientific information and interesting references to scientists that are included in the general material. The style is clear and simple; technical terms are defined as they are introduced.

The book is divided into three parts. Part One emphasizes the outstanding features of Taxonomy, Ecology, Palaeontology, Anthropology, Cytology, Histology, Embryology, and Pathology. In Part Two are grouped chapters dealing with the mechanisms of metabolism and reproduction including the integument, systems of digestion, circulation, respiration and excretion, together with the glands of internal secretion. Part Three is concerned with the mechanisms of motion and sensation.

This book is recommended as a reference source for biology students in high school and as a text for college students in vertebrate zoology.

LYLE F. STEWART

THE PHYLUM CHORDATA, by H. H. Newman, *Professor of Zoology in the University of Chicago*. A Revision of *Vertebrate Zoology*. Cloth. Pages xiv+477. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Prince $3.60.

This text covers the whole Phylum Chordata, with emphasis upon the evolutionary history of the group, the interrelations of surviving groups, general principles illustrated by the group and significant aspects of their natural history.

The first five chapters serve as a setting or introduction for the remainder of the text by describing the primitive true chordates and Hemichordata in addition to emphasizing the outstanding characteristics of the phylum and the principles of vertebrate evolution. The remaining nineteen chapters include the following information: Primitive Veretebrates (description and classification), Pisces (general characteristics, shark-like fishes of the past and present, anatomy of a generalized vertebrate—dogfish, bony fishes, teleost fishes), Amphibia (origin, past and present status, extinct orders, living representatives, anatomy of a generalized tetrapod—salamander), Reptilia (dramatic career of the reptiles, changes incident to terrestrial life, fossil pedigree of reptiles, modern reptilian orders), Aves (distinguishing characteristics, structures compared with those of an aeroplane, general anatomy, origin and ancestry, general classification, birds of today, embryonic development), Mammalia (distinguishing characters, anatomy, origin and early evolution, Monotremes and Marsupials, orders of Placental Mammals, development or life-history of Marsupials and Placental Mammals).

This is an excellent textbook for college classes in vertebrate zoology. It is especially adapted for courses where the laboratory work and lectures are essentially independent, though supplementary.

LYLE F. STEWART

MATHEMATICS REVIEW EXERCISES, by David P. Smith, Jr., and Leslie T. Fagan, both *Masters in Mathematics in the Lawrenceville School, New Jersey*. Cloth. Pages vii+280. 14.5×23 cm. 1940. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.28.

This book is a collection of problems designed to cover the topics included in the College Entrance Examination Beta and Gamma requirements. Most of the problems were taken from the College Entrance Examination Board's papers.

The subjects included are Algebra and Arithmetic, Plane and Solid Geometry, Trigonometry and Advanced Algebra. There are also a few sections of correlated exercises which require a unified knowledge of algebra, geometry, and trigonometry.

The book has many attractive features, not the least of these being the clear and attractive manner of presentation of the problems. There is an excellent classified section which enables the reader to find problems for a particular topic in the above mentioned subjects. The book should prove very useful as a supplement to the regular textbook in all high schools and even in some college courses.

B. FRIEDMAN
Wilson Junior College, Chicago

LIVING MATHEMATICS, by Ralph S. Underwood, *Professor of Mathematics, Texas Technological College*, and Fred W. Sparks, *Professor of Mathematics, Texas Technological College*. Cloth. Pages ix+365. 15×23 cm. 1940. The McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $3.00.

The objects of this textbook are two fold: first, to provide enough of the conventional subject matter to meet practical credit-transfer requirements and second to foster an appreciation of the place of mathematics in modern life.

The book provides a one-year course for those students who, presumably, will not take any more mathematics. The first part covers the fundamentals of algebra such as removal of parentheses, addition of fractions and the laws of exponents. The second part deals with some of the highlights in trigonometry, analytic geometry and calculus, winding up with a slight discussion of probability and the theory of numbers.

The book is written in an amusing and jaunty style which, though it may shock by its novelty, will probably help in keeping the students interested.

B. FRIEDMAN
Wilson Junior College, Chicago

PLANE GEOMETRY, REVISED EDITION, by A. M. Welchons and W. R. Krickenberger, *The Arsenal Technical High School, Indianapolis, Indiana*. Cloth. Pages x×502. 14×20 cm. 1940. Ginn and Co., Boston, Mass. Price $1.40.

In this revision attempt has been made to include such topics as space geometry, everyday reasoning, and some elementary analytic geometry. The text follows many of the recently accepted suggestions for the teaching of geometry. There are many objective tests scattered throughout the

book. Whether or not the special features of the book offer a decided advantage over other recently published texts is probably a matter of personal opinion. Some might question the implication that the primary purpose of geometry is to teach the pupil how to reason. Others might feel that this is of prime importance and that the applications to everyday reasoning are very well selected.

Occasional historical notes, illustrations of applications of geometry in various fields, and suggestions that there are subjects too difficult for the high school student are unquestionably of value. On page 413, the statement that π is transcendental because it cannot be the root of an algebraic equation is perhaps incomplete.

CECIL B. READ
University of Wichita

PRACTICAL ALGEBRA WITH GEOMETRICAL APPLICATIONS, by John H. Wolfe, *supervisor of Apprentice School, Ford Motor Co.;* William F. Mueller, A.B., *Head of Mathematics Dept., Ford Apprentice School;* and Siebert D. Mullikin, B.S., *Instructor of Mathematics, Ford Apprentice School.* Cloth. Pages xiii+314. 12×20 cm. 1940. McGraw-Hill Book Co. New York, New York. Price $2.20.

The authors state that this book is an outgrowth of the need felt in the apprentice school for a practical geometrical algebra. One cannot glance through the book without recognizing the emphasis upon practical application. There seems to be, however, no neglect of fundamental algebraic principles. One is impressed by the many reproductions of shop drawings.

The last chapter emphasizes gear and cam problems. A considerable portion is devoted to numerical trigonometry. A 5 place table of natural trigonometric functions is included. Even without a knowledge of customary practice in the industry, one is led to wonder at the complete absence of any treatment of logarithms.

Even if the text should not seem suitable in some course it would seem an excellent reference book for the library. It should furnish a very effective answer for the student who sees no practical use in algebra.

CECIL B. READ
University of Wichita

THE THEORY OF GROUP CHARACTERS AND MATRIX REPRESENTATIONS OF GROUPS by Dudley E. Littlewood. Cloth. Pages viii+292. 16.5×24.5 cm. 1940. Oxford at the Clarendon Press (Oxford University Press, London). Price $5.50.

In the words of the author, the purpose of this book is to give a simple and self-contained exposition of the theory of group characters and to develop some of its contacts with other branches of pure mathematics. The first three chapter are devoted to matrices, algebras, and groups. It is assumed that this covers the specialized knowledge which might be required of the reader. Granted that any college graduate with a major in mathematics should be able to read the work, it is rather doubtful that all such individuals would be able to do so. The method of presentation is frequently quite concise, although rigorous, and requires careful reading.

Following the introductory three chapters, the author discusses the concept of a Grobenius algebra, showing the relationship to simple matrix algebras, and procedes to the definition of a group character. Among other topics treated are the symetric group; a method for the calculation of the characters of any group, (it is shown how many of the important properties of a group may be deduced from its table of characters); matrix groups; invariant matrices.

A bibliography of 77 items includes most of the original memoirs on each topic. At various points mention is made, directly or indirectly, of problems which remain to be solved.

CECIL B. READ
University of Wichita

JUNIOR MATHEMATICS, Books 1, 2 and 3, by Harl A. Douglass, *Director, College of Educat'on University of Colorado,* and Lucien B. Kinney, *Associate Professor of Education, Stanford University.* Cloth. Book 1, vii+440 pages; Book 2, vii+439 pages; and Book 3, vii+504 pages, 12.5×20 cm. 1940. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y.

Once, let us say twenty years ago, textbooks in mathematics were concerned mainly with arranging such topics as fractions, decimals, and percentage in a logical order; many everyday problems were treated only briefly and even such topics as insurance and taxes were treated very sketchily. It would be easy to go to the other extreme and handle so many type of applications that the pupil failed to learn the fundamentals. The problem of every author is that of obtaining a proper balance between the extremes. To obtain a balance an author must be more than a scientist or psychologist or a good pedagogue. He must also be an artist—an artist with a sixth or seventh sense who intuitively feels when he has gone far enough in one direction, when he has treated one topic sufficiently, and when the pupils are losing interest in fractions and would like to hear something about insurance or taxes. And this series of books appear to be written by artists who understand the pupils for whom they are working.

The titles of the chapters in Book 3, for example, are: How Mathematics is used in Producing Food and Clothing. Organizing a Business. How Ratio help in Measurement. Personal Credit. Providing for Economic Security. Using the Right Triangle in Measurement. Government Activities and Expenditures. Statistical Methods Applied to Earnings, Health, and Safety. Mathematics in Scientific Work. What Algebra is and Some of its Uses. What Geometry is Like. Diagnostic and Remedial Program. But titles alone cannot indicate the nature of the treatment. Care has been taken to teach the fundamentals, to give meaning to all concepts. There are inventory tests, schock absorbers as preparations for tests, review exercises, remedial drills, tests in the form of hurdles, problem scales, and vocabulary check-ups. One objection is that it takes, in book 3,500 pages to accomplish all this. Only an experienced teacher could find his way through so much material; and the pupil would doubtless feel, at the end of the year, that he has accomplished very little or what has been set before him.

JOSEPH A. NYBERG
Hyde Park High School, Chicago

MATHEMATICS FOR TODAY, Books 1 and 2, by Harl R. Douglass, *Director, College of Eucation, University of Colorado,* and Lucien B. Kinney, *Associate Professor of Education, Stanford University.* Cloth. Book 1, vii+437 pages; Book 2, vii+447 pages. 12.5×20 cm. 1940. Henry Holt and Company, 257 Fourth Avenue, New York, N.Y.

EVERYDAY MATHEMATICS, by Harl R. Douglass, *Director, College of Education, University of Colorado,* and Lucien B. Kinney, *Associate Professor of Education, Stanford University.* Cloth. Pages vii+503. 1940. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y.

The two volumes of *Mathematics for Today* and the *Everyday Mathematics* are essentially a rearrangement of the material in the three-book series by the same authors, reviewed above. The *Junior Mathematics* series contains 32 units or chapters. Nine of these and one new unit make up Book 1 in *Mathematics for Today;* seven of them and four new units make up Book 2; and nine of them and two new ones make up the *Everyday Mathematics*. In the rearrangement of the material, however, the same order of the topics was not always followed. Thus, in *Everyday Mathematics* the unit of Government Activities and Expenditures precedes the unit on Personal Credit, and the latter precedes the unit on Organizing a Business. But the order of these units is the reverse of that in Book 3 of the *Junior Mathematics*. In *Everyday Mathematics* the unit on Statistical Methods precedes the one on Providing for Economic Security, but in Book 3 this order is reversed. Again, in Book 2 of *Mathematics for Today*, Mathematics in Buying and Selling precedes How we Use the Bank; but in Book 2 of the *Junior Mathematics* this order is reversed. One can conclude that much of the material in all six volumes has been so written that the teacher need not always follow the order of presentation in the books. We may regard these rearrangements as proof that each unit is well written and that the course of study is flexible.

The preface of *Everyday Mathematics* states that this text has been influenced by the suggestions in Chapter VI of the Report of the Joint Commission on the Place of Mathematics in Secondary Education. However, the algebraic, graphic, trigonometric and other work suggested on pages 103 to 107 of this report are entirely missing from *Everyday Mathematics*. Those pages state quite clearly that the course should survey the field of high school mathematics so that the pupil can see that mathematics consists of more than arithmetic. Book 3 of the *Junior Mathematics* is a slightly better approximation to the report since it contains at least some work on algebra, geometry, and the trigonometric ratios. But in both books many of the recommendations have been disregarded. Disregarding this feature, teachers will find that all six volumes contain a wealth of material, exceptionally well presented and organized.

JOSEPH A. NYBERG
Hyde Park High School, Chicago

NEW POPULAR SCIENCE BOOKS

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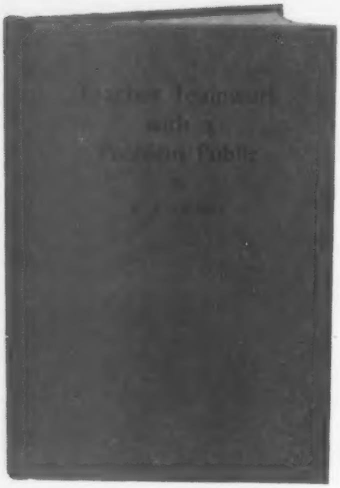

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